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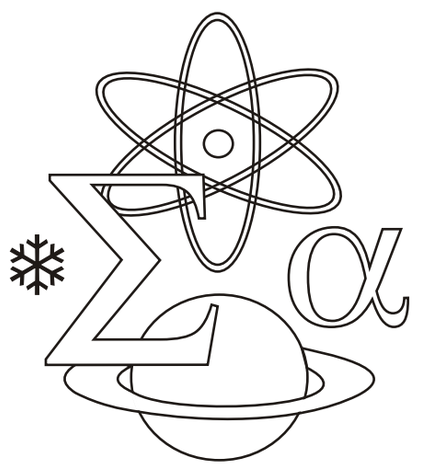

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ORDERED SEMIGROUPS WITH COMMUTING BI-IDEALS

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ABSTRACT

We characterize ordered semigroups that decompose as a semilattice of $\mathcal{B}$-simpleordered semigroups as those ordered semigroups in which ordered bi-ideals form asemilattice under the multiplication of subsets. We also investigate le-semigroups inwhich bi-ideal elements commute with each other and prove that in such semigroupseach $\mathcal{B}$-class B that satisfies the condition $B^2 \cap B \neq \varnothing$, forms a subsemigroup.

Keywords: ordered semigroup, semilattice decomposition, bi-ideal

1. INTRODUCTION AND PRELIMINARIES

The decomposition of a semigroup as a semilattice of certain type of semigroups have played a central role in the theory of semigroups and the problem of characterizing such decompositions in terms of ideals or their generalizations has been a reoccurring theme in the theory.

For example, it was proved in (Sait, 1973) that a semigroup *S*is a semilattice of left simple semigroups,if and only if the set of left ideals of *S* is a semilattice under the multiplication of subsets. Asimilar result was proved in(Lajos, 1971) where he characterizes Clifford semigroups as thosesemigroups whose bi-ideals form a semilattice under the multiplication of subsets. In analogy with (Sait, 1973), Kehayopulu and Tsingelis (2013) proved that an ordered semigroup *S* decomposesas a semilattice of left simple ordered semigroups if and only if the set of ordered left idealsforms a semilattice under the multiplication of subsets.

The present paper aims to prove a similar decomposition theorem to that of Kehayopuluand Tsingelis where ordered left ideals are replaced by ordered bi-ideals. More precisely weprove that an ordered semigroup *S* decomposes as a semilattice of $\mathcal{B}$-simple ordered semigroups if and only if the set of its ordered bi-ideals form a semilattice under the multiplicationof subsets. Motivated by the above result and dropping the condition of the idempotency

ofthe bi-ideals, we study those *le*-semigroups in which bi-ideal elements commute and provethat in such semigroups any $\mathcal{B}$-class *B*which satisfies the Green condition ($B^2 \cap B \neq \varnothing$)forms a subsemigroup. Further we use this to show without the aid of results from (Kehayopulu and Tsingelis, 2013) that*po*-semigroups in which bi-ideals form a semilattice decompose into a semilattice of $\mathcal{B}$-simplesemigroups.

In what follows we give some of the notions that are used throughout the paper.

A *po-semigroup* (*ordered semigroup*) is a triple $(S,\cdot,\leq)$ where $\leq$ is an order relation in*S* and $\cdot$ is a multiplication in *S* that satisfy the properties

$$a \leq b \Rightarrow xa \leq xb \text{ and } ax \leq bx \text{ for all } x \in S$$

If $(S,\cdot,\leq)$ is a *po*-semigroup possessing a greatest element e, then it will be called a *poe*-semigroup and it is called a $\vee e$-semigroup if $(S,\leq)$ is an upper semilattice. If in addition it happens that $(S,\leq)$ is a lattice (the meet $\wedge$ and the joint $\vee$ of any two elements of S exists), then S will be called a *le*-semigroup. The standard notation for the *le*-semigroup in this case is $\langle S,\cdot,\vee,\wedge\rangle$. Here, the order relation is not made explicit but it is understood that $a \leq b$ iff $a \wedge b = a$. An element x of S is called a right (resp. left) ideal element if $xe \leq x$ (resp. $ex \leq x$). It is called an ideal element if it is both a left and a right ideal element of *S*. An element x of *S* is called a bi-ideal element if $xex \leq x$. It is clear that one-sided idealelements of *S* are at the same time bi-ideal elements. In terms of one sided ideal elements, Kehayopulu (1989; 1990) has defined the following equivalences in a *le*-semigroup

$$\mathcal{L} = \{(x,y) \in S \times S \mid x \vee ex = y \vee ey\},$$
$$\mathcal{R} = \{(x,y) \in S \times S \mid x \vee xe = y \vee ye\},$$
$$\mathcal{H} = \mathcal{R} \cap \mathcal{L}$$

While in terms of bi-ideal elements Kehayopulu (1995) has defined in the following equivalence relation

$$\mathcal{B} = \{(x,y) \in S \times S \mid x \vee xex = y \vee yey\}.$$

An element x of a *le*-semigroup *S* is called regular if $x \leq xex$, and intra-regular if $x \leq ex^2x$.It is called semisimple if $x \leq exexe$.

A nonempty subset *A* of a po-semigroup $(S,\cdot,\leq)$ is called a left ideal of *S* if

(1) $SA \subseteq A$ and
(2) if $a \in A$ and $b \in S, b \le a$, then $b \in A$, that is if $(A] = A$.

For an element *a* of *S*, we denote by *L(a)* the left ideal of *S* generated by *a*. We have $L(a) = (a \cup Sa]$.

We give here a slightly different definition of bi-ideals in *po*-semigroups than the onegiven in (Kehayopulu, 1998). A nonempty subset *B* of a *po*-semigroup $(S, \cdot, \le)$ is called a bi-ideal of *S* if

(1) $(BSB] \subseteq B$;
(2) if $b \in B$ and $b' \in S, b' \le b$, then $b' \in B$, that is if *(B] = B* and
(3) *(B]* is a subsemigroup of *S*.

An ordered semigroup $(S, \cdot, \le)$ is called *left regular* if for every $a \in S$ there exist $x \in S$ such that $a \le xa^2$, equivalently if $a \in (Sa^2]$ for every $a \in S$. A po-semigroup *S* is calledleft simple (resp. $\mathcal{B}$-simple) if *S* is the only left ideal (resp. bi-ideal) of *S*. We say that a*po*-semigroup *S* decomposes as a semilattice of left simple (resp. $\mathcal{B}$-simple) *po*-semigroupsif there exists a semilattice *Y* and a family $\{S_\alpha : \alpha \in Y\}$of left simple (resp. $\mathcal{B}$-simple) *po*-subsemigroups of *S* such that:

1) $S_\alpha \cap S_\beta = \varnothing$; for all $\alpha \ne \beta$ in *Y*,
2) $S = \cup\{S_\alpha : \alpha \in Y\}$,
3) $S_\alpha \cdot S_\beta \subseteq S_{\alpha\beta}$.

This definition is equivalent to assuming the existence of a congruence σ on S such that forevery $a, b \in S, (ab, ba) \in \sigma$ and $(a, a^2) \in \sigma$. In fact the classes of σ are the subsemigroups S_α of the above decomposition.

2 A decomposition theorem for *po*-semigroups

As aforementioned said, the aim of this section is to prove an analogue of theorem 6 of (Kehayopulu and Tsingelis, 2013) where the term ordered left ideal is replaced by ordered bi-ideal.

Theorem 2.1*Let* $(S, \cdot, \le)$ *be a po-semigroup. The following are equivalent:*
(1) S is a semilattice of $\mathcal{B}$*-simple semigroups.*

(2) If B_1, B_2 *and* B *are bi-ideals of* S*, then* $(B_1B_2] = (B_2B_1], (B^2] = B$ and $B_1 \cap B_2 = (B_1B_2]$.

(3) If B_1, B_2 *are bi-ideals of* S, then $B_1 \cap B_2 = (B_1B_2]$.

Proof. $(1) \Rightarrow (2)$. Let $c \in (B_1B_2]$, then there are $b_1 \in B_1$ and $b_2 \in B_2$ such that $c \leq b_1b_2$. Denoting by σ the congruence assumed in the theorem, we have that $(b_1b_2)_\sigma = (b_2b_1)_\sigma$. Thefact that $b_1b_2 \in (b_1b_2)_\sigma$ and that $(b_2b_1)_\sigma$ is $\mathcal{B}$-simple, imply that there is $x \in S$ such that $b_1b_2 \leq b_2b_1 \cdot x \cdot b_2b_1$. Hence $c \leq b_2b_1 \cdot x \cdot b_2b_1$ and then

$$\begin{aligned} c \in (b_2b_1 \cdot x \cdot b_2b_1) &\subseteq (B_2B_1 \cdot S \cdot B_2B_1] \\ &\subseteq (B_2SB_2B_1] && \text{since } B_1S \subseteq S \\ &\subseteq (B_2B_1] && \text{since is } B_2 \text{ a bi-ideal,} \end{aligned}$$

showing that $(B_1B_2] \subseteq (B_2B_1]$. The reverse inclusion is proved in a similar fashion, thus wehave the equality $(B_1B_2] = (B_2B_1]$.

Let us now prove that $(B^2] = B$ for every bi-ideal B of S. For every $b \in B, b \in (b)_\sigma$ but $(b)_\sigma$ forms a subsemigroup of S and then $b^2 \in (b)_\sigma$. The fact that $(b)_\sigma$ is $\mathcal{B}$-simple implies that there is some $x \in S$ such that $b \leq b^2xb^2$, hence $b \in (B^2SB^2] \subseteq (B^2]$ which proves that $B \subseteq (B^2]$. The reverse inclusion follows from the fact that $B = (B]$ is by definition asubsemigroup of S.

Finally, we prove that $B_1 \cap B_2 = (B_1B_2]$. First, we observe that for every bi-ideal B of$S$ we have that *(B] = (BSB]*. To see this, we recall that conditions that bi-ideals areidempotent and commute with each other imply that the same holds true for left ideals asspecial cases of bi-ideals, then theorem 6 (5) of (Kehayopulu and Tsingelis, 2013) implies that S is left regular. Then,

$$\begin{aligned} B &\subseteq (SB^2] && \text{from left-regularity} \\ &= (BSB] \subseteq (B] && \text{since bi-ideals commute,} \end{aligned}$$

proving that *(B] = (BSB]*. Let now B_1 and B_2 be two bi-ideals of S, then

$$\begin{aligned}(B_1B_2] &= (B_1B_2SB_2] && \text{from the above observation}\\ &= ((B_1B_2]SB_2] = ((B_2B_1]SB_2] && \text{since bi-ideals commute}\\ &= (B_2B_1SB_2] \subseteq (B_2SB_2] && \text{since } B_1S \subseteq S\\ &= (B_2].\end{aligned}$$

In the same way, one proves that $(B_1B_2] \subseteq (B_1]$, hence $(B_1B_2] = (B_2B_1] \subseteq B_1 \cap B_2$ showingthat $B_1 \cap B_2$ is non empty and therefore a bi-ideal of *S* as the intersection of two bi-ideals.

But once again bi-ideals are idempotent and so

$$B_1 \cap B_2 = (B_1 \cap B_2)^2 \subseteq (B_1B_2],$$

implying $B_1 \cap B_2 = (B_1B_2]$.

$(2) \Rightarrow (1)$. We remark again that the conditions we are assuming imply that everythingclaimed in theorem 6 of (Kehayopulu and Tsingelis, 2013) holds true since left ideals are at the same time bi-ideals as well.In particular we have that for every $a \in S$ the left ideal *L(a)*of *S* generated by *a* equals to*(Sa*]. We show that the same holds true for the bi-ideal *B(a)* of *S* generated by *a*. Indeed,

$$\begin{aligned}B(a) = S \cap B(a) &= (S \cdot B(a)] && \text{from the assumption}\\ = (S(a \cup aSa]] &= (Sa \cup SaSa] = (Sa] = L(a) && \text{from the above.}\end{aligned}$$

The equality *B(a)* = *L(a)* shows that $\mathcal{B} = \mathcal{L}$ in *S*, hence the decomposition of *S* into $\mathcal{B}$-classes is a semilattice decomposition of left simple subsemigroups. We prove that each $\mathcal{B}$-class $(a)_{\mathcal{B}}$ is in fact $\mathcal{B}$-simple by proving that every bi-ideal *B* of $(a)_{\mathcal{B}}$ is in fact a left idealof $(a)_{\mathcal{B}}$ and therefore $B = (a)_{\mathcal{B}}$ from the left simplicity of $(a)_{\mathcal{B}} = (a)_{\mathcal{L}}$. To this end we assume $y \in ((a)_{\mathcal{B}}B]$ hence $y \le \alpha \cdot b$ where $\alpha \in ((a)_{\mathcal{B}}]$ and $b \in B$. It follows that $\alpha \le a'$ where a' is agenerator of *B(a)*. Since *B* is a bi-ideal of $(a')_{\mathcal{B}}$, then $B(a')_{\mathcal{B}}B \subseteq B$, and for every $b_1, b_2 \in B$

$$B(b_1a'b_2) = B(a'),$$

or equivalently

$$(b_1a'b_2 \cdot Sb_1'ab_2] = (a' \cdot S \cdot a'].$$

The latter implies that there is some $x \in S$ such that $a' \leq b_1xb_2$. It follows that $y \leq b_1xb_2b$,but $b_1xb_2b \in (BSB] \subseteq (B]$, hence $y \in (B]$ proving that $((a)_{\mathcal{B}}B] \subseteq (B]$ which shows that $(a)_{\mathcal{B}}$ is a left ideal as claimed.

$(2) \Rightarrow (3)$. This is trivial.

$(3) \Rightarrow (2)$. Since $B_1 \cap B_2 = (B_1B_2]$, then $B_1 \cap B_2 = (B_2B_1]$, hence $(B_1B_2] = (B_2B_1]$.

Taking $B_1 = B_2 = B$ weobtain $B = B \cap B = (BB] = (B^2]$.■

3 An application to the plain semigroups

In this short section, we will apply the result of theorem 2.1 to the case where the orderrelation on a given semigroup $(S,\cdot)$ is defined by setting $\leq := \{(a,b) \in S \times S : a = b\}$. Itis clear that such an order semigroup $(S,\cdot,\leq)$ is nothing but the plain semigroup $(S,\cdot)$. Anordered bi-ideal in this case is just a usual bi-ideal, that is a subsemigroup $B \subseteq S$ such that $BSB \subseteq B$.

Theorem 3.1*Let* $(S,\cdot)$ *be a semigroup. The following are equivalent:*

(1) S is a semilattice of $\mathcal{B}$ *-simple semigroups.*

(2) If B_1, B_2 *and B are bi-ideals of S, then* $B_1B_2 = B_2B_1, B^2 = B$ and $B_1 \cap B_2 = B_1B_2$.

(3) If B_1, B_2 *are bi-ideals of S, then* $B_1 \cap B_2 = B_1B_2$.

Proof. $(1) \Rightarrow (2)$. It is straightforward from $(1) \Rightarrow (2)$ of theorem 2.1 if we recall that inthe unordered case $(B_1B_2] = B_1B_2$.

$(2) \Rightarrow (3)$. This is evident.

$(3) \Rightarrow (1)$. Condition (3) characterizes semilattices of groups (cf. theorem 11, (Lajos, 1971)). Thus,*S* is a semilattice of groups and each of these groups is a $\mathcal{B}$ -simple semigroup. This provescondition (1).■

The following immediate corollary of theorem 3.1 and theorem 11 of (Lajos, 1971) does not seem toappear in the literature.

Corollary 3.1*A semigroup* $(S,\cdot)$ *is a semilattice of groups if and only if it is a semilatticeof* $\mathcal{B}$ *-simple semigroups.*

The sufficiency of the above can be also proved by using (2) of theorem 3.1 and theorem12 of (Lajos, 1971) which characterizes semilattices of groups as those semigroups whose bi-ideals formsa semilattice under multiplication of subsets.

4 Passing from le-semigroups to po-semigroups

If $(S,\cdot,\leq)$ is an ordered semigroup, then we can extend S to an ordered semigroup with aleast element which is at the same time a multiplication zero. This is done by adding to San element 0 and defining to $S^0 = S \cup \{0\}$ a new multiplication $*$ and a new order $\leq_0$ by

$$a * b = \begin{cases} ab & \text{if} \quad a,b \in S \\ 0 & \text{if} \quad a = 0 \text{ or } b = 0 \end{cases} \quad \text{and} \quad \leq_0 := \leq \cup \{(0,x) \mid x \in S\}.$$

Now if $(S,\cdot,\leq)$ is an ordered semigroup and $\varnothing \neq A \subseteq S^0$, we denote

$$(A]_0 := \{x \in S^0 \mid x \leq_0 y \text{ for some } y \in A\}.$$

It is obvious that $(A]_0 = (A] \cup \{0\}$ where $(A] = \{x \in S \mid x \leq y \text{ for some } y \in S\}$. Further welet

$$\sum = \{(A]_0 \mid \varnothing \neq A \subseteq S^0\}.$$

In $\sum$ define a multiplication $\circ$ and a partial order $\leq$ by

$$(A]_0 \circ (B]_0 := (A * B]_0 \text{ and } (A]_0 \leq (B]_0 \text{ iff } (A]_0 \subseteq (B]_0.$$

It is proved in (Kehayopulu and Pasku et al, 2006) that $(\sum,\circ,\subseteq)$ forms a *le*-semigroup with the biggest element S where themeet and join are given by

$$(A]_0 \wedge (B]_0 = (A \cap B]_0, (A]_0 \vee (B]_0 = (A \cup B]_0.$$

Also, it is proved that $(S,\cdot,\leq)$ embeds into $(\sum,\circ,\subseteq)$ by the map $a \mapsto (a]$.

The result of the following lemma is crucial in the rest of the section.

Lemma 4.1 *If B is a bi-ideal of S, then* $(B]_0$ *is a bi-ideal element of* $\sum$. *Conversely, if* $(B]_0$ *is a bi-ideal element of* $\sum$, *then* $B' = B \setminus \{0\}$ *is a bi-ideal of S.*

Proof. For the if part, we see that

$$\begin{aligned} (B]_0 \circ S \circ (B]_0 &= (B * S * B]_0 && \text{from the definition of } \circ \\ &= (BSB]_0 \subseteq (B]_0 && \text{since } B \text{ is a bi-ideal of } S. \end{aligned}$$

For the converse, we have:

$$\begin{aligned} B'SB' &\subseteq (B'SB'] \subseteq (B'SB']_0 \\ &= (B * S * B]_0 = (B]_0 \circ S \circ (B]_0 \subseteq (B]_0 \quad \text{since } (B] \text{ is a bi-ideal element.} \end{aligned}$$

But $B'SB' \subseteq S$, hence $B'SB' \subseteq (B'] = B'$ proving the claim.■

Before we prove our main result of this section we consider the following situation.

Let $\langle S, \cdot, \vee, \wedge \rangle$ be an *le*-semigroup with the greatest element e in which any two bi-idealelements commute with each other. We call this property **B**. Assume that B_β is a $\mathcal{B}$-class of$S$satisfying the Green condition. The element β is the representative bi-ideal element of theclass. The class B_β will be denoted by $B_\beta^{(e)}$ in order to avoid confusion with another classthat will be introduced later. Since $B_\beta^{(e)}$ satisfies the Green condition, then from (Pasku and Petro, 2002) we know that β is an idempotent and that every element of $B_\beta^{(e)}$ is intra-regular, therefore $\beta \leq e\beta e$.

This and the fact that β is the greatest element of the class imply that

$$B_\beta^{(e)} \subseteq (e\beta e] = \{x \in S \mid x \leq e\beta e\}.$$

This observation will be beneficial as will be shown in sequel. First we note that $(e\beta e]$ is asubsemigroup of S and with the order relation induced there $(e\beta e]$ becomes an *le*-semigroupwith the greatest element $e\beta e$. Let $B_\beta^{(e\beta e)}$ the $\mathcal{B}$-class of β in $(e\beta e]$. Note here that β is a bi-ideal of $(e\beta e]$ since

$$\beta(e\beta e)\beta = (\beta e\beta)(e\beta) \leq \beta(e\beta) \leq \beta.$$

Being a bi-ideal, it will be the greatest element of the class hence its representative bi-ideal element. If we recall that our *le*-semigroup $\langle S, \cdot, \vee, \wedge \rangle$ has the property that every twobi-ideal elements commute with each other, then we see that $e\beta e$ is an idempotent since

$$\begin{aligned} e\beta e &\geq e\beta e \cdot e\beta e \geq \beta \cdot e\beta e \\ &= e \cdot \beta \cdot \beta e && \text{by condition } \mathbf{B} \\ &= e\beta e && \text{since is } \beta \text{ an idempotent.} \end{aligned}$$

Proposition 4.1*Let* $\langle S, \cdot, \vee, \wedge \rangle$ *be a le-semigroup with the greatest element* e *in whichevery two bi-ideal elements commute with each other. Then any* $\mathcal{B}$*-class satisfying the Greencondition is a subsemigroup of* S.

Proof. As before we denote by $B_\beta^{(e)}$ the given $\mathcal{B}$-class and by $B_\beta^{(e\beta e)}$ the $\mathcal{B}$-class of β in $(e\beta e]$.We show that $B_\beta^{(e)} \subseteq B_\beta^{(e\beta e)}$. Indeed, for every $x \in B_\beta^{(e)}$ the following hold true

$$\begin{aligned}
\beta = xex \vee x &\geq x \cdot e\beta e \cdot x \vee x \\
&\geq xe \cdot e\beta e \cdot ex \vee x = ex \cdot xe \cdot e\beta e \vee x && \text{by condition } \mathbf{B} \\
&= e\beta^2 e \cdot e\beta e \vee x && \text{since } ex = e\beta \text{ and } xe = \beta e \\
&= e\beta e \vee x && \text{since } e\beta e \text{ is an idempotent} \\
&= \beta e^2 \vee x && \text{by condition } \mathbf{B} \\
&\geq \beta e \vee x \geq \beta && \text{since } x \leq \beta = \beta e \beta \leq \beta e.
\end{aligned}$$

Next, we prove that $B_\beta^{(e\beta e)}$ is a subsemigroup of $(e\beta e]$. Let $x, y \in B_\beta^{(e\beta e)}$. Since $B_\beta^{(e)} \subseteq B_\beta^{(e\beta e)}$ and $B_\beta^{(e)}$ satisfies the Green condition, then $B_\beta^{(e\beta e)}$ satisfies the condition too and then from(Pasku and Petro, 2002) we have that

$$e\beta e \cdot x \cdot e\beta e = e\beta e \cdot y \cdot e\beta e = \beta.$$

But from condition **B**

$$e\beta e \cdot x \cdot e\beta e = e\beta e \cdot e\beta e \cdot x = e\beta e \cdot x,$$

hence $e\beta e \cdot x = \beta$. In the same way we get that $x \cdot e\beta e = \beta$. In particular we have that $\beta \cdot e\beta e = \beta$ and $e\beta e \cdot \beta = \beta$. Since $\beta = \beta e \beta$ we get that $\beta e = \beta$ and $e\beta = \beta$, consequently $e\beta e = \beta$ and from the above we have that

$$e\beta e \cdot x = x \cdot e\beta e = e\beta e = \beta.$$

Further we have

$$\begin{aligned}
\beta &\geq \beta^2 \cdot e\beta e \cdot \beta^2 \vee \beta^2 \geq xy \cdot e\beta e \cdot xy \vee xy \\
&= xy \cdot \beta \cdot y \vee xy = xy \cdot e\beta e \cdot y \vee xy \\
&= x \cdot e\beta e \cdot y \vee xy = e\beta e \vee xy = \beta \vee xy = \beta,
\end{aligned}$$

which proves that $xy \in B_\beta^{(e\beta e)}$. Finally, we show that $B_\beta^{(e)}$ forms a semigroup. Let $x, y \in B_\beta^{(e)}$.Since $B_\beta^{(e)} \subseteq B_\beta^{(e\beta e)}$ and since from the above $B_\beta^{(e\beta e)}$ is a semigroup, then $xy \in B_\beta^{(e\beta e)}$ and so

$$xy \cdot e\beta e \cdot xy \vee xy = \beta.$$

We now have

$$\beta \geq xy \cdot e \cdot xy \vee xy \geq xy \cdot e\beta e \cdot xy \vee xy = \beta,$$

proving that $xy \in B_{\beta}^{(e)}$.■

We now turn back to show how to pass from $\sum$ where *S* embeds to *S* itself.

Lemma 4.2*For every* $x \in S$, *the* $\mathcal{B}$*-class* B_x^S *of x in S includes via* ι *in the* $\mathcal{B}$*-class* $B_{(x]_0}^{\Sigma}$ *of* $(x]_0$ *in* $\sum$.

Proof. If $y \in B_x^S$, then

$$(ySy \cup y] = (xSx \cup x],$$

hence

$$(y * S * y \cup y]_0 = (x * S * x \cup x]_0,$$

or equivalently

$$(y]_0 \circ S \circ (y]_0 \vee (y]_0 = (x]_0 \circ S \circ (x]_0 \vee (x]_0,$$

proving that $y \in B_{(x]_0}^{\Sigma}$ and therefore the inclusion $\iota(B_x^S) \subseteq B_{(x]_0}^{\Sigma}$.■

Lemma 4.3*If* $(S, \cdot, \leq)$ *is a po-semigroup in which the set of bi-ideals forms a semilatticeunder the multiplication of subsets, then the same holds true with the set of bi-ideal elements of* $(\sum, \circ, \subseteq)$ *where S embeds. Furthermore, the set of* $\mathcal{B}$*-classes of* $\sum$ *forms a semilattice.*

Proof. Let $(A]_0, (B]_0$ be two bi-ideal elements of $\sum$ and A', B' be their respective bi-idealsof lemma 4.1 for which we know that

$$A'B' = B'A' \text{ and } A'^2 = A'.$$

Then,

$$(A]_0 \circ (B]_0 = (A' * B']_0 = (A'B']_0 = (B'A']_0 = (B' * A']_0 = (B]_0 \circ (A]_0,$$

and

$$(A]_0^2 = (A]_0 \circ (A]_0 = (A' * A']_0 = (A'A']_0 = (A']_0 = (A]_0,$$

proving the first claim.

To prove the second claim, let $B_{(C]_0}^{\Sigma}, B_{(D]_0}^{\Sigma}$ be two $\mathcal{B}$-classeswhere $(C]_0$ and $(D]_0$ are therespective representative bi-ideal elements of the classes. If $(X]_0 \in B_{(C]_0}^{\Sigma}$ and $(Y]_0 \in B_{(D]_0}^{\Sigma}$, then

$$\begin{aligned}
(X]_0 \circ (Y]_0 \circ S &\circ (X]_0 \circ (Y]_0 \vee (X]_0 \circ (Y]_0 \\
&= (X]_0 \circ (Y]_0 \circ S \circ S \circ (X]_0 \circ (Y]_0 \vee (X]_0 \circ (Y]_0 && S \text{ is an idempotent} \\
&= (X]_0 \circ S \circ (X]_0 \circ (Y]_0 \circ S \circ (Y]_0 \vee (X]_0 \circ (Y]_0 && \text{from condition B} \\
&= (C]_0 \circ (D]_0 && \text{from (Pasku and Petro, 2002),}
\end{aligned}$$

hence $(X]_0 \circ (Y]_0 \in B^{\Sigma}_{(C]_0 \circ (D]_0}$ completing the proof.■

Corollary 4.1*If* $(S,\cdot,\leq)$ *is a po-semigroup in which the set of bi-ideals forms a semilatticeunder the multiplication of subsets, then S decomposes as a semilattice of* $\mathcal{B}$*-simple semi-groups.*

Proof. From lemma 4.3 we have that $\sum$ satisfies **B** and the bi-ideal elements are idempotents,hence from proposition 4.1 each $\mathcal{B}$-class of $\sum$ is a subsemigroup. On the other hand, lemma4.2 shows that for any $x \in S, B^S_x$ can be regarded as a subset of $B^{\Sigma}_{(x]_0}$ which in turn is asubsemigroup, hence B^S_x is a subsemigroup of *S*. Indeed, let $y, z \in B^S_x$, then

$$(ySy \cup y] = B = (zSz \cup z],$$

where $B = (xSx \cup x]$. Since $B^{\Sigma}_{(x]_0}$ is a subsemigroup, then

$$(y]_0 \circ (z]_0 \circ S \circ (y]_0 \circ (z]_0 \vee (y]_0 \circ (z]_0 = (B]_0,$$

which implies that

$$(yzSyz \cup yz] = B,$$

and as a result that $yz \in B^S_x$. Secondly, to show that the decomposition of *S* into $\mathcal{B}$-classes isa semilattice decomposition, it is sufficient to find an indexing of the $\mathcal{B}$-classes by a semilatticein such a way that the multiplication of the $\mathcal{B}$-classes agrees with the multiplication of theirrespective indexes. This is easily done by assigning to each class B^S_x the bi-ideal β_x of *S*generated by *x* and denoting the class by $B^S_{\beta_x}$ instead of B^S_x. For any pair of classes $B^S_{\beta_x}, B^S_{\beta_y}$ we see that

$$\begin{aligned} B^S_{\beta_x} \cdot B^S_{\beta_y} &\cong \iota(B^S_{\beta_x}) \circ \iota(B^S_{\beta_y}) \\ &\subseteq B^{\Sigma}_{(\beta_x]_0} \circ B^{\Sigma}_{(\beta_y]_0} \quad \text{by lemma 4.2} \\ &\subseteq B^{\Sigma}_{(\beta_x]_0 \circ (\beta_y]_0} \quad \text{by lemma 4.3} \\ &= B^{\Sigma}_{(\beta_x\beta_y]_0} = B^{\Sigma}_{(\beta_{xy}]_0} \quad \text{since } xSx \cdot ySy = xySxy, \end{aligned}$$

which shows that the image $\iota\left(B^S_{\beta_x} \cdot B^S_{\beta_y}\right)$ of $B^S_{\beta_x} \cdot B^S_{\beta_y}$ in $\sum$ includes in $B^{\Sigma}_{(\beta_{xy}]_0}$, hence

$$\iota(B^S_{\beta_x}) \circ \iota(B^S_{\beta_y}) \subseteq \iota(S) \cap B^{\Sigma}_{(\beta_{xy}]_0}.$$

But $B^S_{\beta_{xy}} \cong \iota(S) \cap B^{\Sigma}_{(\beta_{xy}]_0}$ where the isomorphism is the restriction of ι on $B^S_{\beta_{xy}}$, and so $\iota(B^S_{\beta_x}) \circ \iota(B^S_{\beta_y}) \subseteq \iota(B^S_{\beta_{xy}})$ showing that $B^S_{\beta_x} \cdot B^S_{\beta_y} \subseteq B^S_{\beta_{xy}}$.

Now we prove the simplicity of the $\mathcal{B}$-classes of S. Since bi-ideal elements of $\sum$ form asemilattice, two conclusions can be drawn. First, it is obvious that the relations $\mathcal{B}$ and $\mathcal{J}$ coincide in $\sum$ and second, $\sum$ is semisimple since for every $(X]_0 \in \sum$,

$$(X]_0 \subseteq (XSX]_0 = S \circ (X]_0 \circ S \circ (X]_0 \circ S.$$

Now proposition 2.3 of (Shasivari and Pasku, 2015) implies that $\mathcal{B}$-classes of $\sum$ are left simple subsemigroups. To seethis, we let B^S_x be any $\mathcal{B}$-class and let $y \in B^S_x$. We first observe that

$$\iota(y \cdot B^S_x \cdot y \cdot \{y\}) = \iota(S) \cap ((y]_0 \circ B^{\Sigma}_{(x]_0} \circ (y]_0 \vee (y]_0). \qquad (1)$$

Further we see that

$$\begin{aligned} (y]_0 \circ B^{\Sigma}_{(x]_0} \circ (y]_0 \vee (y]_0 &= B^{\Sigma}_{(x]_0} \circ (y]^2_0 \vee (y]_0 \quad \text{by condition } \mathbf{B} \\ &= B^{\Sigma}_{(x]_0} \vee (y]_0 = B^{\Sigma}_{(x]_0} \quad \text{since } B^{\Sigma}_{(x]_0} \text{ is left simple.} \end{aligned}$$

If we replace in (1) $(y]_0 \circ B^{\Sigma}_{(x]_0} \circ (y]_0$ by $B^{\Sigma}_{(x]_0}$ we obtain

$$\iota(y \cdot B^S_x \cdot y \cup \{y\}) = \iota(S) \cap B^{\Sigma}_{(x]_0},$$

and since $\iota(S) \cap B^{\Sigma}_{(x]_0}$ equals to $\iota(B^S_x)$ we obtain that $\iota(y \cdot B^S_x \cdot y \cup \{y\}) = \iota(B^S_x)$ which

proves that B^S_x is $\mathcal{B}$-simple.■

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GENERALIZED WEAKLY Γ-DIVISION RINGS

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ABSTRACT

In this paper, firstly we define generalized weakly Γ-division rings and show when a laminated weakly Γ-ring of a ring with respect to its laminated set, is a generalized weakly Γ-division ring. Further, we study generalized weakly Γ-division rings, showing especially when they are weakly Γ-division rings. Lastly, we find a necessary and sufficient condition for a generalized weakly Γ-division ring to be a completely inverse weakly Γ-ring, defining preliminarily the latter one.
Keywords: Weakly Γ-ring, weakly Γ-division ring, completely inverse weakly Γ-ring, generalized weakly Γ-division ring.

1. INTRODUCTION

In this paper, by convention, a weakly Γ-ring, which was defined by Petro and Sema (2010) will be referred to as a Γ-ring.

Due to the concept of division ring, Sema and Petro (2014) have defined and studied weakly Γ-division rings, that here will be simply called Γ-division rings.

Inverse rings, which are nothing but 0-rings, were defined and studied by Sain (1970). They have similar properties to division rings and may serve in a natural way to introduce inverse Γ-rings, which have similar properties to Γ-division rings.

By means of the concept of lamination of rings, that was adapted from the concept of lamination of near-rings, we prescribe laminated rings and by means of them we define laminated Γ-rings of rings with respect to their laminatory sets. Also, we show necessary and sufficient conditions that

laminated Γ-rings of a ring with respect to their laminatory sets, be generalized Γ-division rings. Further we find equivalent propositions for a Γ-ring to be a generalized Γ-division ring, as well as a necessary and sufficient condition for a generalized Γ-division ring to be a Γ-division ring. Lastly, defining preliminarily completely inverse Γ-rings and using Green's Theorem for Γ-semigroups, we give a necessary and sufficient condition for a generalized Γ-division ring to be a completely inverse Γ-ring. In the end of the paper it is raised an open problem.

2. PRELIMINARIES

Here we give some notions and present some auxiliary results that will be used throughout the paper.

Let M and Γ be two nonempty sets. Any map from $M \times \Gamma \times M$ to M is called a Γ-multiplication on M and is denoted by $(\cdot)_\Gamma$. The result of this Γ-multiplication, for every $a, b \in M$, and every $\gamma \in \Gamma$, is denoted by $a\gamma b$.

Definition 2.1. Sen and Saha (1986) said that a Γ-semigroup is called any ordered pair $(M, (\cdot)_\Gamma)$, where M and Γ are two nonempty sets and $(\cdot)_\Gamma$ is a Γ-multiplication on M, which satisfies the following condition:

$$\forall (a, b, c, \alpha, \beta) \in M^3 \times \Gamma^2, (a\alpha b)\beta c = a\alpha(b\beta c).$$

Let $(M, (\cdot)_\Gamma)$ be a Γ-semigroup and A, B two nonempty subsets of M. We write:

$$A\Gamma B = \{a\gamma b : a \in A, \gamma \in \Gamma, b \in B\}.$$

Definition 2.2. Sen and Saha (1986) said that a right [left] ideal of the Γ-semigroup $(M, (\cdot)_\Gamma)$ is a subset R $[L]$ of M such that $R\Gamma M \subseteq R$ $[M\Gamma \mathrm{L} \subseteq L]$.

For each element a of a Γ-semigroup M, the principal right [left] ideal $(a)_r$ $[(a)_l]$ generated by a, is the intersection of all right [left] ideals of M, containing a.

Saha (1987) has defined the Green's relations $\mathcal{R}, \mathcal{L}, \mathcal{H}$ in a Γ-semigroup M, as follows:

$$\forall (a, b) \in M^2, a\mathcal{R}b \Leftrightarrow (a)_r = (b)_r,$$
$$\forall (a, b) \in M^2, a\mathcal{L}b \Leftrightarrow (a)_l = (b)_l,$$
$$\forall (a, b) \in M^2, a\mathcal{H}b \Leftrightarrow (a)_r = (b)_r \wedge (a)_l = (b)_l.$$

One can prove that $\mathcal{R}, \mathcal{L}, \mathcal{H}$ are equivalence relations. The respective equivalence classes of $a \in M$ are denoted by R_a, L_a, H_a.

Let $(M, (\cdot)_\Gamma)$ be a Γ-semigroup and keep $\gamma \in \Gamma$ fixed. As in Sen and Saha (1986), define $a \circ_\gamma b = a\gamma b$. It is obvious that $\circ_\gamma$ is asocciative. Hence, we

obtain a plain semigroup $(M,\circ_\gamma)$ which is also denoted by (M,γ) or shortly by M_γ.

Theorem 2.3. (Greens Theorem for Γ-semigroups) If the elements $a,b,a\gamma b$ of a Γ semigroup M all belong to the same $\mathcal{H}$-class H_a of M, then H_a is a subgroup of the semigroup (M,γ). Moreover, for any two elements $h_1,h_2 \in H_a, h_1\gamma h_2$ belongs to H_a. Petro and Xhillari (2011)

Definition 2.4. Petro and Sema, (2010) said that a weakly Γ-ring is called any ordered triple $(M,+,(\cdot)_\Gamma)$, where M, Γ are two nonempty sets, $+$ is an addition on M, and $(\cdot)_\Gamma$ is a Γ-multiplication on M, such that:

1) $(M,+)$ is an abelian group.
2) $(M,(\cdot)_\Gamma)$ is a Γ-semigroup.
3) $\forall(a,b,c,\gamma) \in M^3 \times \Gamma, [(a+b)\gamma c = a\gamma c + b\gamma c] \wedge [a\gamma(b+c) = a\gamma b + a\gamma c]$.

We notice that plain rings, Γ-rings of Nobusawa, Nobusawa (1964) and the Γ-rings of Barnes, Barnes (1966), which in the literature are called Γ-rings, are weakly Γ-rings, but the converse is not true.

Let $(M,+,(\cdot)_\Gamma)$ be a Γ-ring and γ a fixed element of Γ. We define the binary operation $\circ_\gamma$ on M, by the equality:

$$a \circ_\gamma b = a\gamma b,$$

for every two elements a,b of M. It is evident that $(M,+,\circ_\gamma)$ is a ring. We denote this ring shortly $(M,+,\gamma)$, or when no confusion M_γ.

Definition 2.5. Let $(M,+,(\cdot)_\Gamma)$ be a Γ-ring. The element $\gamma \in \Gamma$ is called a Γ-zero if for every two elements a,b of M, we have $a\gamma b = 0$. Sema and Petro (2014)

If $(M,+,(\cdot)_\Gamma)$ is a Γ-ring, then the set of the elements of Γ, that are different to Γ-zero is denoted by Γ_0.

Definition 2.6. Sema and Petro (2014) said that a Γ-ring $(M,+,(\cdot)_\Gamma)$ is called a weakly Γ-division ring if $\Gamma_0 \neq \emptyset$ and for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is a division ring.

Definition 2.7. Sain (1970) said that a ring $(A,+,\cdot)$ is called a 0-ring if its multiplicative semigroup $(A,\cdot)$ is an inverse semigroup.

In this paper, 0-rings will be referred to as inverse rings.

Definition 2.8. The semigroup $(S,\cdot)$ is called a completely inverse semigroup if it is inverse and every two mutually inverse elements are permutable. Petro (1983)

Definition 2.9. The ring $(A,+,\cdot)$ is called a completely inverse ring if its multiplicative semigroup $(A,\cdot)$ is a completely inverse semigroup. Petro (1988)

Definition 2.10. The ring A is called strongly regular if for every $a \in A$, there exists an element $b \in A$ such that $a = a^2 b$. Sain (1970)

Proposition 2.11. Every inverse ring A is completely inverse. Sain (1970)

Proposition 2.12. The ring A is strongly regular if and only if it is an inverse ring. Sain (1970)

Definition 2.13. A near-ring $(N,+,\cdot)$ is called a generalized near-field if its multiplicative semigroup $(N,\cdot)$ is an inverse semigroup. Murty (1984)

Theorem 2.14. The near-ring M is a generalized near-field and integral if and only if M is a near-field. Murty (1984)

Magill (1980) has introduced the concept of the laminated near-ring. Let $(N,+,\cdot)$ be any near-ring. Each element a of N yields a new near-ring $N_a = (N,+,*)$, where $(N,+)$ is the additive group of the near-ring $(N,+,\cdot)$ and $*$ is the multiplication on N defined by $x * y = xay$, for every two elements x,y of N. The near-ring N_a is called a *laminated near-ring* of N with respect to the *laminator* a.

Proposition 2.15. Let a be a nonzero element of a near-ring N. Then the laminated near-ring N_a of N is a generalized near-field if and only if N is a generalized near-field and $Na = N$. Yakabe (1988).

Theorem 2.16. Yakabe (1988) said that the following conditions on a near-ring N that has at least two elements are equivalent:

1) Each laminated near-ring of N with respect to each nonzero laminator is a generalized near-field.

2) N is a near-field.

3) Each laminated near-ring of N with respect to each nonzero laminator is a near-field.

4) Some laminated near-ring of N with respect to some nonzero laminator is a near-field.

All unexplained notes, concepts and propositions were taken by Clifford and Preston (1964), Steinfeld (1978) and Pilz (1983).

3. MAIN RESULTS

Let $(M,+,\cdot)$ be an arbitrary ring and a a fixed element of M. We define the multiplication $\circ_a$ on M, by means of the equality

$$x \circ_a y = xay,$$

for every two elements x,y of M, where xay is the product of the elements x,a,y under the multiplication of the ring $(M,+,\cdot)$.

Then one can easily verify that $(M,+,\circ_a)$, where $+$ is the addition of the ring $(M,+,\cdot)$, is a ring. We shall denote this ring by $(M,+,a)$ and when no confusion, we shall denote it shortly M_a and call it *laminated ring* of the ring $(M,+,\cdot)$, with respect to the *laminator* a.

Due to the approach of the concept of laminated ring with that of laminated near-ring, by theorem 2.16 we get this theorem:

Theorem 3.1. In a ring M, that has at least two elements, the following conditions are equivalent:

1) Each laminated ring of M with respect to each nonzero laminator is an inverse ring.
2) M is a division ring.
3) Each laminated ring of M with respect to each nonzero laminator is a division ring.
4) Some laminated ring of M with respect to some nonzero laminator is a division ring.

Let $(M,+,(\cdot)_\Gamma)$ be a Γ-ring, such that $\Gamma_0 \neq \emptyset$. For every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ may have different properties. Under the same properties, for all these rings, we have different kinds of Γ-rings. One of them, is the Γ-division ring, for which all the rings $(M,+,\gamma)$, $\gamma \in \Gamma_0$ are plain division rings. Inverse rings have similar properties to division rings. So, by means of them, we can define a class of Γ-rings, which contains the class of Γ-division rings, as its subclass.

Definition 3.2. A Γ-ring $(M,+,(\cdot)_\Gamma)$, such that $\Gamma_0 \neq \emptyset$, is called by us a generalized Γ-division ring (without the convention, a generalized weakly Γ-division ring) if for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is an inverse ring.

Let us denote by Γ an arbitrary nonempty subset of elements of the ring $(M,+,\cdot)$. Define the Γ-multiplication $(\cdot)_\Gamma$ on M, such that for every two elements x,y of M and for every $\gamma \in \Gamma, x\gamma y$ is the product of the elements x,γ,y in the ring $(M,+,\cdot)$. It is not difficult to show that the ordered triple $(M,+,(\cdot)_\Gamma)$, where $+$ is the addition of the ring $(M,+,\cdot)$, is a Γ-ring. We shall call this Γ-ring, *laminated* Γ*-ring* of the ring $(M,+,\cdot)$, with respect to the *laminatory set* Γ.

Example 3.3. Let X be any nonempty set. Take the set $\Gamma = \{\emptyset, X\}$ in the ring $(P(X),\cup,\cap)$. One can prove that the laminated Γ-ring of the ring $(P(X),\cup,\cap)$ with respect to the laminatory set $\Gamma = \{\emptyset, X\}$ is a generalized Γ-division ring.

If $(M,+,\cdot)$ is a division ring, then one can easily prove that the laminated Γ-ring $(M,+,(\cdot)_\Gamma)$, with respect to each laminatory set Γ, which has at least one nonzero element, is a Γ-division ring, too.

An arbitrary ring $(M,+,\cdot)$ is a near-ring, and when this near-ring is a near-field, then $(M,+,\cdot)$ is nothing but a division ring.

Using theorem 3.1 for Γ-rings, we find the following:

Theorem 3.4. For every nonzero ring, the following propositions are equivalent:

1) The ring $(M,+,\cdot)$ is a division ring.

2) Each laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ of the ring $(M,+,\cdot)$ with respect to each laminatory set Γ, that has at least one nonzero element, is a Γ-division ring.

3) There exists a laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ of the ring $(M,+,\cdot)$ with respect to a laminatory set Γ, which has at least one nonzero element, that is a Γ-division ring.

4) Each laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ of the ring $(M,+,\cdot)$ with respect to each laminatory set Γ, that has at least one nonzero element, is a generalized Γ-division ring.

Proof. 1) ⇒ 2). Suppose that proposition 1) is true. For every set $\Gamma \subseteq M$, which has at least one nonzero element and for every $\gamma \in \Gamma_0$, due to Theorem 3.1, the ring $(M,+,\gamma)$ is a division ring. So, the laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ with respect to the laminatory set Γ, is a Γ-division ring.

The implication 2) ⇒ 3) is evident.

3) ⇒ 4). Suppose that proposition 3) is true. Let $\overline{\Gamma}$ be any set of elements of M, that has at least one nonzero element, such that its laminated $\overline{\Gamma}$-ring $(M,+,(\cdot)_{\overline{\Gamma}})$ is a $\overline{\Gamma}$-division ring. For every $\gamma \in \overline{\Gamma}_0$, the ring $(M,+,\gamma)$ is a division ring. So, due to Theorem 3.3, the ring $(M,+,\cdot)$ is a division ring. Let now $(M,+,(\cdot)_\Gamma)$ be a laminated Γ-ring of the ring $(M,+,\cdot)$ with respect to an arbitrary laminatory set Γ, that has at least one nonzero element. Due to Theorem 3.1, for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is an inverse ring. So, the laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ of the ring $(M,+,\cdot)$ with respect to each laminatory set Γ, that has at least one nonzero element, is a generalized Γ-division ring.

4) ⇒ 1). Suppose that proposition 4) is true. Then, by taking $\Gamma = M^* = M\backslash\{0\}$, the laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ with respect to the laminatory set Γ, is a generalized Γ-division ring. Thus, for every $\gamma \neq 0$, the ring $(M,+,\gamma)$ is an inverse ring. Now, by Theorem 3.1, the ring $(M,+,\cdot)$ is a division ring. ■

By Proposition 2.15 we get the following:

Proposition 3.5. Let a be a nonzero element of the ring $(M,+,\cdot)$. Then the laminated ring $M_a = (M,+,a)$ is an inverse ring if and only if $(M,+,\cdot)$ is an inverse ring and $Ma = M$.

From this proposition we have this corollary:

Corollary 3.6. Let $(M,+,\cdot)$ be an inverse ring. Denote

$$\Gamma = \{a \in M^* : Ma = M\}.$$

If $\Gamma_0 \neq \emptyset$, then the laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ of the ring $(M,+,\cdot)$ with respect to the laminatory set Γ, is a generalized Γ-division ring. Furthermore, if $\Gamma = M^*$, then the laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ is a Γ-division ring.

Proof. Let γ be an arbitrary element of Γ_0. Since $M\gamma = M$ and the ring $(M,+,\cdot)$ is an inverse ring, due to Proposition 3.5 the laminated ring $M_\gamma = (M,+,\gamma)$ with respect to the laminator γ, is an inverse ring. So, the laminated Γ-ring $(M,+,(\cdot)_\Gamma)$ of the ring $(M,+,\cdot)$ with respect to the laminatory set Γ, is a generalized Γ-division ring. If the set Γ coincides with the set M^*, then the laminated Γ-ring with respect to the laminatory set Γ, is a Γ-division ring. Indeed, in this case for every $a \neq 0$, we have that $Ma = M$ and consequently the ring $(M,+,\cdot)$ has no proper left ideals, thus it is a division ring Steinfeld (1978). Hence, the laminated Γ-ring with respect to the laminatory set Γ, is a Γ-division ring. ■

By Theorem 2.14 we immediately obtain the following theorem for rings:

Theorem 3.7. A ring M is a division ring if and only if M is inverse and integral.

In order to find an analogous theorem to Theorem 3.7 for Γ-rings, we first define integral Γ-ring.

Definition 3.8. Let $(M,+,(\cdot)_\Gamma)$ be a nonzero Γ-ring, such that $\Gamma_0 \neq \emptyset$. The nonzero element a of M is called a zero divisor, if there exist a nonzero element b of M and a $\gamma_0 \in \Gamma_0$, such that

$$a\gamma_0 b = 0 \vee b\gamma_0 a = 0.$$

The Γ-ring $(M,+,(\cdot)_\Gamma)$ is called integral, if it has no zero divisors.

It is evident that the Γ-ring $(M,+,(\cdot)_\Gamma)$, which has at least a nonzero element and $\Gamma_0 \neq \emptyset$ is integral if and only if it is true the following proposition:

$$\forall (a,\gamma,b) \in M \times \Gamma \times M, a\gamma b = 0 \Rightarrow (a = 0 \vee \gamma \notin \Gamma_0 \vee b = 0).$$

Theorem 3.9. A Γ-ring $(M,+,(\cdot)_\Gamma)$ is a Γ-division ring if and only if it is a generalized division Γ-ring and integral.

Proof. Suppose that the Γ-ring $(M,+,(\cdot)_\Gamma)$ is a Γ-division ring. Then, for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is a division ring. For every $a \neq 0$ of M, there exists the unique element a^{-1} of M, such that

$$a\gamma a^{-1} = a^{-1}\gamma a = e_\gamma,$$

where e_γ is the identity element of the division ring $(M,+,\gamma)$. Hence, we have:

$$a\gamma a^{-1}\gamma a = a \wedge a^{-1}\gamma a\gamma a^{-1} = a^{-1}.$$

Thus, the element a^{-1} is an inverse element of the element a. If the element $b \in M$ is an inverse element of a in the ring $(M,+,\gamma)$, then we have:

$$a\gamma b\gamma a = a \wedge b\gamma a\gamma b = b.$$

Hence, we would find that the element b is nothing but the inverse element a^{-1} of a in the division ring $(M,+,\gamma)$. For the zero element of the ring $(M,+,\gamma)$, zero is its unique inverse element, thus $(M,+,\gamma)$ is an inverse ring, and consequently the Γ-ring $(M,+,(\cdot)_\Gamma)$ is a generalized Γ-division ring.

On the other hand, for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ has no zero divisors, since it is a division ring. So, for every element $a \neq 0$, for every element $b \neq 0$ and for every $\gamma \in \Gamma_0, a\gamma b \neq 0$ and $b\gamma a \neq 0$, consequently the Γ-ring $(M,+,(\cdot)_\Gamma)$ is a generalized Γ-division ring that has no zero divisors, i.e it is integral.

Conversely, let $(M,+,(\cdot)_\Gamma)$ be a generalized Γ-division ring and integral. Then for every $\gamma \in \Gamma_0$, the inverse ring $(M,+,\gamma)$ has no zero divisors, thus it is integral. So, due to Theorem 3.7, the ring $(M,+,\gamma)$ is a division ring and consequently $(M,+,(\cdot)_\Gamma)$ is a Γ-division ring. ■

The following theorem gives equivalent definitions of a generalized Γ-division ring.

Theorem 3.10. Let $(M,+,(\cdot)_\Gamma)$ be a Γ-ring such that $\Gamma_0 \neq \emptyset$. The following propositions are equivalent:

1) The Γ-ring $(M,+,(\cdot)_\Gamma)$ is a generalized Γ-division ring.
2) For every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is completely inverse.
3) For every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is strongly regular.
4) For every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is regular and intra-regular.

Proof. 1) ⇒ 2). Suppose that proposition 1) is true. Thus, for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is an inverse ring. Due to Proposition 2.11, the inverse ring $(M,+,\gamma)$ is completely inverse.

The implication 2) ⇒ 1) is true due to the definition of the completely inverse ring and of the generalized Γ-division ring.

The implication 1) ⇒ 3) is evident.

3) ⇒ 1). Suppose that proposition 3) is true. From Proposition 2.12, we have that for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is an inverse ring and consequently $(M,+,(\cdot)_\Gamma)$ is a generalized Γ-division ring.

3) ⇒ 4). Suppose that proposition 3) is true. Thus, the ring $(M,+,\gamma)$ is strongly regular for every $\gamma \in \Gamma_0$. It is known that when a ring is strongly regular, then every of its quasi-ideals is idempotent Kovacs (1956), whereas when every quasi-ideal of a ring is idempotent, then it is a regular and intra-regular ring Steinfeld (1978).

4) ⇒ 3). Suppose that proposition 4) is true. Kovacs, (1956) and Steinfeld (1978) also proved the converses of the propositions that we mentioned in the proof of implication 3) ⇒ 4). So, for every $\gamma \in \Gamma_0$, the regular and intra-regular ring $(M,+,\gamma)$ is strongly regular and consequently the proposition 3) is true. ■

Definition 3.11. An element a of a Γ-ring $(M,+,(\cdot)_\Gamma)$ is called regular, if there exist an element b of M and two elements α,β of Γ, such that:

$$a = a\alpha b\beta a.$$

A Γ-ring $(M,+,(\cdot)_\Gamma)$ is called regular, if every its element is regular.

Definition 3.12. An element b of the Γ-ring $(M,+,(\cdot)_\Gamma)$ is called an (α,β)-inverse element of the element $a \in M$, if:

$$a = a\alpha b\beta a, \quad b = b\beta a\alpha b.$$

A Γ-ring $(M,+,(\cdot)_\Gamma)$ is called an inverse Γ-ring (without the convention, an inverse weakly Γ-ring) if it is regular and when for every element a of M and for every two elements α,β of Γ, there exists an (α,β)-inverse element of a, then it is unique.

Definition 3.13. An element b of a Γ-ring $(M,+,(\cdot)_\Gamma)$ is called (α,β)-completely inverse element of the element $a \in M$ if the following equalities are true:

$$a = a\alpha b\beta a, \quad b = b\beta a\alpha b, \quad a\alpha b = b\beta a.$$

A Γ-ring $(M,+,(\cdot)_\Gamma)$ is called a completely inverse Γ-ring (without the convention, a completely inverse weakly Γ-ring) if it is inverse and when for every element $a \in M$ and for every two elements α,β of Γ, if b is an (α,β)-inverse element of a, then it is (α,β)-completely inverse element of a.

The element b of the Γ-ring $(M,+,(\cdot)_\Gamma)$ that is (α,α)-inverse [(α,α)-completely inverse] of the element $a \in M$, will be called shortly α-inverse [α-completely inverse] of a.

Proposition 3.14. Let $(M,+,(\cdot)_\Gamma)$ be a Γ-ring. For all $\gamma \in \Gamma$, every element $a \in M$, has at most one γ-completely inverse element.

Proof. Suppose that b,c are two γ-completely inverse elements of the element $a \in M$. Then the following equalities are true:

$$a = a\gamma b\gamma a, \quad b = b\gamma a\gamma b, \quad a\gamma b = b\gamma a,$$

$$a = a\gamma c\gamma a,\ \ c = c\gamma a\gamma c,\ \ a\gamma c = c\gamma a.$$

It is easy to prove that by these equalities, in the Γ-semigroup $(M,(\cdot)_\Gamma)$ we have:

$$(a)_l = (b)_l = (c)_l = (a\gamma b)_l = (a\gamma c)_l,$$
$$(a)_r = (b)_r = (c)_r = (a\gamma b)_r = (a\gamma c)_r.$$

So, the elements:

$$a, b, a\gamma b, c, a\gamma c$$

belong to the same $\mathcal{H}$-class H_a of the element a of the Γ-semigroup $(M,(\cdot)_\Gamma)$. Now, from Green's Theorem for Γ-semigroups (Theorem 2.3), we have that H_a is a subgroup of the semigroup (M,γ). In the subgroup H_a, the following equalities are true:

$$a = a\gamma b\gamma a,\ \ a = a\gamma c\gamma a,$$

from which we find:

$$b = a^{-1}\gamma a\gamma a^{-1} = a^{-1},$$
$$c = a^{-1}\gamma a\gamma a^{-1} = a^{-1},$$

where a^{-1} is the inverse element of a in the subgroup H_a of the semigroup (M,γ). Thus, $b = c$. ■

Theorem 3.15. A completely inverse Γ-ring $(M,+,(\cdot)_\Gamma)$ such that $\Gamma_0 \neq \emptyset$, is a generalized Γ-division ring if and only if for every $\gamma \in \Gamma_0$ and for every $a \in M$, there exists an element $b \in M$, which is γ-inverse element of a.

Proof. Suppose that the completely inverse Γ-ring $(M,+,(\cdot)_\Gamma)$, such that $\Gamma_0 \neq \emptyset$, is a generalized Γ-division ring. Then, for every $\gamma \in \Gamma_0$, the ring $(M,+,\gamma)$ is an inverse ring and consequently for every $a \in M$, there exists an element $b \in M$, such that:

$$a = a\gamma b\gamma a,\ \ b = b\gamma a\gamma b.$$

So, the element b of M is γ-inverse element of a.

Conversely, suppose that the completely inverse Γ-ring $(M,+,(\cdot)_\Gamma)$ where $\Gamma_0 \neq \emptyset$, is such that for every $\gamma \in \Gamma_0$ and for every $a \in M$, there exists an element $b \in M$, which is γ-inverse element of a. Thus,

$$a = a\gamma b\gamma a,\ \ b = b\gamma a\gamma b.$$

Since $(M,+,(\cdot)_\Gamma)$ is a completely inverse Γ-ring, it follows from Proposition 3.14, that the element $b \in M$ is the unique γ-inverse element of a. Thus, the ring $(M,+,\gamma)$ is an inverse ring and consequently $(M,+,(\cdot)_\Gamma)$ is a generalized Γ-division ring. ■

The following theorem gives a necessary and sufficient condition for a generalized Γ-division ring to be completely inverse.

Theorem 3.16. A necessary and sufficient condition for a generalized Γ-division ring $(M,+,(\cdot)_\Gamma)$ to be completely inverse is:

$$\forall(x,\alpha,y,\beta) \in M \times \Gamma \times \mathrm{M} \times \Gamma, (x = x\alpha y\beta x \wedge y = y\beta x\alpha y) \Rightarrow (x\alpha y = y\beta x). (*)$$

Proof. It follows from the definition of the completely inverse Γ-ring, that condition $(*)$ is necessary.

Sufficient condition. Suppose that condition $(*)$ holds for the generalized Γ-division ring $(M,+,(\cdot)_\Gamma)$. To show that $(M,+,(\cdot)_\Gamma)$ is completely inverse, it suffices to show that it is an inverse Γ-ring. It is evident that the generalized Γ-division ring $(M,+,(\cdot)_\Gamma)$ is regular.

Let b,c be two (α,β)-inverse elements of the arbitrary element a of M. The following equalities hold:

$$a = a\alpha b\beta a,\ \ b = b\beta a\alpha b,\ \ a\alpha b = b\beta a,$$

$$a = a\alpha c\beta a,\ \ c = c\beta a\alpha c,\ \ a\alpha c = c\beta a,$$

which show that in the Γ-semigroup $(M,(\cdot)_\Gamma)$ we have:

$$(a)_l = (b)_l = (c)_l = (a\alpha b)_l = (a\alpha c)_l = (b\beta a)_l = (c\beta a)_l,$$
$$(a)_r = (b)_r = (c)_r = (a\alpha b)_r = (a\alpha c)_r = (b\beta a)_l = (c\beta a)_r.$$

So, the elements

$$a, b, c, a\alpha b, a\alpha c, b\beta a, c\beta a$$

belong to $\mathcal{H}$-class H_a of the element a of the Γ-semigroup $(M,(\cdot)_\Gamma)$. From Green's Theorem for Γ-semigroups (Theorem 2.3) we have that H_a is a subgroup of the semigroups (M,α) and (M,β). Since in (M,α) we have

$$a = a\alpha(b\beta a) = a\alpha(c\beta a),$$

in (M,β) we find:

$$b\beta a = c\beta a.$$

Hence, we have $b = c$. So, $(M,+,(\cdot)_\Gamma)$ is an inverse Γ-ring. ■

Lastly, we raise the following problem, that we leave open:

Problem. Does Theorem 3.16 hold, if we search that $(M,+,(\cdot)_\Gamma)$ be only an inverse Γ-ring?

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IMPROVING MEASUREMENTOF ABILITIES OF STUDENTS IN TEST ASSESSMENTS FROM CLASSICAL TEST THEORY TO MODERN TEST THEORY

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ABSTRACT

Classical Test Theory (CTT) and Modern Test Theory are widely perceived as representing two very different measurement frameworks. Few studies have empirically examined the similarities and differences in the parameters estimated using the two frameworks. This study investigates the behavior of item statistics (i.e., item difficulty and item discrimination) and person statistics (i.e., ability estimates) under the two measurement frameworks. Modern Test Theory or the so-called Item Response Theory (IRT) focuses on item characteristics.The present paper investigates the differential ability for the students ranking on a multiple-choice test. In CTT, a student attempting a difficult question and an easy question get the same number of credits; unlikely forthe IRT. In addition, in the CTT two students with equal raw scores have the same ranking while in IRT they have different ranking.We have chosen randomly a test module from the set of 45 test modules that was given to the National Agency of Exams for thelicense of general practitioners. Digitizedstate examsprocedures involve the computer-based test[1] of candidates' knowledge, by using a number of random generated questions preselected and stored in a related database. The test module is uploaded to each candidate's computer. All the test modules fulfill the same standards. 50 multiple alternative items were used as instrument for the assessment of the 54 candidates. The test results were evaluated applying the CTT and IRT. Results reported that the IRTis the most appropriate method for an accurate evaluation.

***Keywords*:** Classical Test Theory, Item Response Theory, ability, item difficulty, item discrimination, ranking of candidates

[1]Computer Base Test / abbrev. CBT

1. INTRODUCTION

Both Classical Test Theory (CTT) and ItemResponse Theory (IRT) are currently being used for the measurement and assessment of candidates ranking on a multiple-choice test.In the CTT, the number of correct score (or overall scores) is often taken as ability —partly correct. As CTT is theoretically applicable, its test statistics are still commonly used in the test construction process.However,itseffectivenessis discussable. Courville (2005) said that the IRTis the answer to thelimitations of Classical Test Theory.As IRTinvolves the unit of assessment to assess thecandidates'performance, it is more accurate.The suitability of both frameworks for the candidates' ranking basingon their ability remains discussable.

CLASSICAL TEST THEORY (CTT)

Classical Test Theory (CTT) is the mostappropriate for traditional testing, either in group or individual settings, in which all the members of a target population are administered the same or parallel sets of test items.This method has a number of underlying assumptions.

In this model, the observed score on a test consists of two components: the true score,i.e., the result of an individual's ability level and the error score, i.e., the result of factors other than the ability being tested. This assumption is shown in this formula:

$$X = X_T + X_E \qquad (1)$$

where:

X = the observed score,
X_T = the true score,
X_E= the error score

As it can be observed, the technical aspect of this assumption is additive, i.e. the true and error scores are added to form the observed score. In other words, the observed score is assumed to be the sum of the true and error scores. Similarly, the variance of a set of test scores can be characterized as comprising two components:

$$S^2_X = S^2_T + S^2_E,$$

where:

S^2_X = the observed score variance,

S^2_T = the true score variance,

S^2_E = the error score variance

Another assumption is that error scores are unsystematic or random and uncorrelated with true scores ($r_{te} = 0$). Therefore, according to the CTT model, measurement error is the variation in a set of test scores that is unsystematic and random.CTT defines two sources of variance in a set of test scores: the true score variance, which is due to differences in the ability of the individuals tested, and measurement error, which is unsystematic or random.In CTT, the most important pieces of information are total scores or raw scores. Every tested studentis given the total score which shows his performance on the whole exam. Items merely play a significant role.

MODERN RESPONSE THEORY (IRT)

IRT is model-based measurement in which trait level estimates depend on both persons' responses and the properties of the items that were administered (EmbrestonandReise,2000).IRT focuses on items rather than overall test scores.

Different IRT models can be characterized in terms of differences intheir general form, and the types of information, or parameters, aboutthe characteristics of the item itself. The types of information about itemcharacteristics may include:i) the degree to which the item discriminates among individualsof differing levels of ability (the 'discrimination' parameter 'a'), ii) the level of difficulty of the item (the 'difficulty' parameter 'b') and, iii) the probability that an individual of low ability can answer theitem correctly (the 'pseudo-chance' or 'guessing' parameter 'c').

The model is presented by the following equation:

$$P(\theta) = c + (1-c)\frac{e^{a\,(\theta-b)}}{1+e^{a\,(\theta-b)}} \qquad (2)$$

In the 1-parameter model (difficulty-parameter) discrimination is taken as 1 and this might not be of great importance if sharp measurement is required, e.g. candidates with equal raw score will have equal IRT score and thus may fail to produce ranking. The model (2) now is presented by:

$$P(\theta) = \frac{e^{(\theta-b)}}{1+e^{(\theta-b)}} = \frac{1}{1+e^{-(\theta-b)}} \qquad (2.1)$$

where:

$b$is the parameter of difficulty,

θ is the level of ability

In 2-parameter model both discrimination and difficulty of items are considered which enablesus to differentiate between the abilities of person with equal raw score. The general model (2) now is presented by:

$$P(\theta) = \frac{1}{1 + e^{-a(\theta - b)}} \qquad (2.2)$$

where:
*b*is the parameter of difficulty,
*a*is the parameter of discrimination,
$\theta$is the level of ability

In 3-parameter modelanother variable *c* is added, i.e., chance factor *c* for item *i* in attempting an item.The general model (2) now is presented by equation:

$$P(\theta) = c + (1 - c)\frac{1}{1 + e^{-a(\theta - b)}} \qquad (2.3)$$

where:
b is the parameter of difficulty,
*a*is the parameter of discrimination,
*c*is the guessing parameter,
$\theta$is the level of ability

If the two and three-parameter item characteristic curve models are used, a student ‘s abilityevaluation depends on the particular pattern of item responses rather than the raw score. Under thesemodels, candidates with the same item response pattern will obtain the same ability estimate. Thus,the candidates with the same raw score could obtain different ability estimates if they answered differentitems correctly(Baker, 2001).This is one of the reasons of whythe 2-parameter model is here usedinstead of 1-parameter mode.IRT modelers assert that on some occasions it is necessary to take discrimination and guessing parameters into account (2p or 3p models). However, in the perspective of 1p modeling, crossing ICCs should not be considered a proper model because construct validity requires that the item difficulty hierarchy is invariant across person abilities (Fisher, 2010).

Item difficulty is the measure of the difficulty of an item. For items (multiple-choice) with one correct alternative worth a single point, the itemdifficulty is defined as the proportion of respondents (candidates) selecting the answer to the item correctly. It is given by equation:

$$p = \frac{c}{n} \qquad (3)$$

where
*p*isthe factor of difficulty,
*c*isthe number of respondents selecting the correct answer to an item,
*n*is totalnumberof respondents

Item difficulty is also known as the item difficulty index, or the difficulty level index, or thedifficulty factor, or the item facility index, or the item easiness index, or the *p* –value. Item difficulty is relevant fordetermining whether candidates have learned the concept being tested. It also plays animportant role in the ability of an item to discriminate between candidates who know thetested material and those who do not.

The item discrimination (or the item discrimination index) is abasic measure of the validity of an item. It is defined as the discriminating power or thedegree of an item's ability to discriminate (or differentiate) between high achievers (thatis, those who scored high on the total test) and low achievers (that is, those who scoredlow). One method for Item Discrimination Index(Brown 1997) is given below.

Let the candidates' test scores be rank-ordered from lowest to highest. So, we can calculate:

$$P_U = \frac{No.\ of\ \ students\ in\ upper\ \ 25\%-30\%\ group\ answering\ \ the\ item\ correctly}{Total\ \ Number\ of\ \ students\ in\ 25\%-30\%\ \ upper\ group} \quad (4)$$

and

$$P_L = \frac{No.\ of\ \ students\ in\ \text{lower}\ \ 25\%-30\%\ group\ answering\ \ the\ item\ correctly}{Total\ \ Number\ of\ \ students\ in\ 25\%-30\%\ \ \text{low}\ group} \quad (5)$$

The item discrimination index D, is given by:

$$D = P_U - P_L \quad (6)$$

A CASE STUDY OF IMPROVING STUDENT COMPARABILITY FROM CTT TO IRT THEORY

Subjects

The participants here involved werecandidates graduated from the University of Medicine as pharmacist. They took the exam for the pharmacistlicense purposes.We have chosen randomly a test module that was given to State Exams for the license of the pharmacistin 2013. Their performance was investigatedbased on person and item statistics.

Instrumentation

One test module that is given to the candidate for profession license comprises50 multiple-choice items.Digitized State Exams involves the Computer-Based Testof candidates' knowledge, by using a number of random generated questions preselected and stored in a related database. The test module is uploaded to each candidate's computer and maximum number of candidates per module is 54. The methods are based on the Classical test

theory and Item Test Theory (IRT). The IRT model that we used was 2-parameter model which is derived from equation (2):

$$p(x_{ij}=1|\theta_j,b_i,a_i)=\frac{\exp^{a_i(\theta_j-b_i)}}{1+\exp^{a_i(\theta_j-b_i)}}=\frac{1}{1+\exp^{-a_i(\theta_j-b_i)}} \qquad (7)$$

where:
a_i isdiscrimination index of item *i*
b_i is difficulty of item *i*

Items with high discrimination parameters have high values of information and are usually preferred over other types of items, especially in computer-adaptive tests (Dodeen, 2004).

Under this model, the candidates with the same item response pattern will obtain the same ability estimate. Thus,the candidates with the same raw score could obtain different ability estimates if they answered different items correctly.

Procedure

It is a computer-based test. Their answers were collected and all answers to all items were entered to the software for analysis. The necessary statistical tests and procedures were carried out to find person statistic (candidate ability estimates) and item statistics (item difficulty and item discrimination).After that, we compared the results of the CTT-based and IRT-based person and item statistics. Then, the similarities and differences between the two models were found to answer the research questions.

Tools

The MATLAB software was involved for the IRTanalyses according to model 2p presenting by equation (7). The CTT model is based on raw scores of candidates.

Description of the test

The test is consisted of a variety of items from verydifficult item with difficulty level of 0.20 to very easy item with difficulty level of 0.85.

Item difficulty of each item in the test was computed applying the formula (3).

To calculate the difficulty level of each item, 27% high achiever and 27% low achiever were taken. Itwas assumed that the responses of the candidates in the middle group follow essentially the same pattern.Item discriminating power of this test items refers to the degree to which it discriminates between candidateswith high and low scores.Discrimination power was computed as the difference between the averagespercent score of high and low achiever, applying equations (5)- (7).

Item characteristics
item format multiple-choice (one of them is correct)
no.of alternatives 4
no.of correct alternatives per item 1
Scoring rubric
maximum scores 50
score correct answer (correct alternative) 1
scores for chosen no alternative 0
score for incorrect alternative 0

An aspect of the flexibility of the multiple-choice format is that, when well-written the format allows assessment of complex and sophisticated mental skills (Osterrlind, 1988).

1. Resultsbased on CTT and IRT models

Table 1 report the results obtained applying the two models. There were 10 candidates involved in each case and the raw scores and the ability scores were compared. Finally, the ranking was made.

Table 1: Results by CTT and IRT model 2p (ability scores)

Candidates	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
CTT model	34	36	33	31	32	31	30	26	30	29
IRT model	2330	2040	1910	1170	1140	1031	1025	955	905	890

The IRT ranking results reported a considerable shift of candidates ranking.The CCT model reported that candidate C2 (score 36)had the highest score, followed by C1 (score 34). IRT ranking reported that candidate C1 (2330 or score 34) was ranked first. Results reported that IRT is the most appropriate method as the student with 34 points selected wrong choices for easy items and got less penalty while candidates with score 36 in CTT relatively could not answer the difficult items and got more penalty consequently lost his ranking.The Table 2compares the raw scores (CTT) and ability scores(IRT) for the first 10candidates.

Table 2: Student rank with IRT and CTT models

Candidates	IRT (ability scores)	Raw score (ability scores)	CTT rank	IRT rank	Difference
C1	2330	34	2	1	-1
C2	2040	36	1	2	1
C3	1910	33	3	3	0
C4	1170	31	6	5	-1
C5	1140	32	4	6	2
C6	1031	31	6	7	1
C7	1025	30	10	8	-2
C8	955	26	16	10	-6
C9	905	30	10	11	1
C10	890	29	15	12	-3

2. CONCLUSIONS AND RECOMMENDATIONS

The results reported that the IRT method is the most appropriate method for an accurate evaluation of candidates' performance.

The resultshere reported are addressed to all the stakeholders involved in the area of education, evaluation of knowledge level.

The more appropriate the method to be applied, the more accurate the evaluation is, as high order skills could be measured. It was observed that the items which were falling in domain of higher cognitive skill were difficult and thus those candidates who responded incorrectly were penalizedand lost scores (Zaman and Atiq, 2008).

CBT system is better, because the results could beautomatically generated and the data saved for further interpretations based oncandidates'ability.

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IMPACT OF MANAGERIAL SKILLS ON THE EFFICIENCY AND EFFECTIVENESS OF ORGANISATIONS (A CASE OF ALBANIAN BUSINESS ORGANISATIONS)

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ABSTRACT

Management skills are crucial to a successful performance. They play an essential role in a manager's efficiency and effectiveness. The present paper investigates the impact of management skills on a manager's efficiency and effectiveness in accordance to the levels of management in Albanian business organizations. Study data were collected through the online questionnaire. The study sample consists of 115 managers working for Albanian and international companies operating in Albania. In order toanalyze the data, SPSS 20 and JASP.0.8.0.1 were used. For the testing of the hypotheses, regression and correlation analyses were employed. The results reported that conceptual skills have the greatest impact on a manager's efficiency and effectiveness. Interpersonal skills have the greatest impact on a manager's efficiency and conceptual skills have a greatest impact on a manager's effectiveness. The main hypothesis and the other hypotheses were accepted with a reliability rate of 95%.

***Keywords*:** managerial skills, conceptual skills, human skills, technical skills, manager's efficiency, manager's effectiveness, levels of management

1. INTRODUCTION

The manager is the most valuable asset of a company. Management studies is becoming more and more the focus of research. This is due to the importance that the manager has in an organization within such a dynamic environment. Every organization needs to be managed in order to maintain a

competitive edge in a fast-paced changing market. Managers in every level of management employ their conceptual, interpersonal and technical skills in order to stay efficient and effective in fulfilling their tasks. However, some questions arise. What are the skills that lead to a manager's efficient and effective performance at the top-level management? What about middle- and low-level management? This study provides the answers to these questions, as these questions are central to this study. The object of the research is the study of the impact of management skills in a manager's efficiency and effectiveness at a given level of management.

2. LITERATURE REVIEW

Management research is conducted all the time in different countries of the world. Various researchers have made contributions to the field. A manager has been defined as someone who coordinates and supervises other people in order to achieve the objectives of the organization (Robbins and Coulter, 2012). Another way of saying this, a manager is someone in the organization, who tells you what to do and shows you the way in which something is done. Welch and Welch (2009) said that, a great boss is someone who is able to change your life, by inspiring you to reach new professional and personal heights. Also, he is able toinstall confidence into a team to face new challenges, which would otherwise be more difficult to handle at an individual level.

But why would managers be indispensable for an organization? Robbins and Coulter (2012) have listed three reasons as to why managers are crucial to organizations.

First, the management skills of managers are very important to the organizations in order to operate in an environment where everything changes constantly. Nowadays, organizations face a multitude of challenges: high uncertainty, complexity, technological developments, and global competition. Managers maintain the lead role in organizations because they identify the critical issues and draw the options for their solutions.

Second, is that managers are essential in getting things done. They do not focus on a single issue, but are preoccupied with the whole process, in order to achieve the desired outcome.

Third, managers are valuable to organizations. A study carried out by the Gallup organizations (2004) revealed that the most important variable that impacted the productitivity and loyalty of employees was a good relationship with their manager. Another study conducted by the international consultancy firm Towers Watson, showed that the way in which the company managed and treated its employees significantly influenced the financial performance of the company. A study conducted into the organization's performance

revealed that management skills were important in value creation in the organization.

A great contribution to the manager's role in the organization has been made by Mintzberg (2009). He concluded from his research that: "In essence, management deals with action influence. It deals with assisting the organization and the unit in getting things done, which implies action." He explained that the manager can accomplish this in three ways: i) managing direct action, ii) managing people and, iii) managing information by motivating people to take action.

Buckingham (2009), in his study showed that the element which sets excellent managers apart from others, is their ability to discover the special qualities in each individual and bringing them to light. According to him, average managers play checkers while exceptional managers play chess. In a game of checkers, the pieces are the same, their movements are much alike and can be exchanged without difficulty. Doubtless, planning and coordination are imperative, but not particularly challenging because all the pieces move in a similar way. On the other hand, in a game of chess, all the pieces move in different ways and in order for someone to play, they need to know their movements. However, in order to win, one needs to have a clear strategy on how to move the pieces. This is what exceptional managers do; they recognize and assess the unique capabilities of each employee and integrate them into their strategy.

The organization is structured according to three levels of management (Robbins and DeCenzo, 2008): i) low-level management, ii) middle-level management and, iii) top-level management.

Low-level management or operational managers deal with the management of employees as well as being involved in organizational processes, such as production or service provision. They communicate directly with employees. Operations managers are at the base of the pyramid of management levels.

Middle-level management manages low-level managers. They focus their attention to the internal operations of a company. They are responsible for drawing detailed plans and procedures in order to achieve the overall objectives of the organization. It is their responsibility to reach the goals set by top-level management.

Top-level management deals with long-term planning. They look at the organization as a whole and set the goals and objectives of the organization. They are responsible for making decisions, outlining long-term strategy and policies, which affect the entire organization. They have power and influence. They sit at the top of the pyramid.

In order for managers to perform successfully, they must employ their management skills with effectiveness. Management skills set successful managers apart from unsuccessful managers.

Katz (1974), in his research "Skills of an Effective Administrator", discovered that the effectiveness of an administrator is influenced by technical, interpersonal (human) and conceptual skills. He viewed each skill connected to the levels of management. According to Katz, technical skills are crucial to low-level management, human skills are crucial to all levels of management and conceptual skills are crucial to top-level management.

In addition to Katz's study, other researchers studied management skills and concluded that a manager must possess four management skills. According to researchers these skills are divided in two groups. In the first group, are those skills that all managers must possess: technical skills, human skills, conceptual skills and political skills. In the second group, are those skills that pertain to the success of a manager: control over the organizations' resources and environment, organization and coordination, handling of information, training and development planning, employee motivation and handling of conflict, and problem-solving (Robbins and DeCenzo, 2008).

Jack Zenger and Joseph Folkman (2014), in their research analyzed management skills through a wider scope. They studied the most used skilled at each level. The study revealed that the motivation of others was the skill with the greatest impact in a manager's success at each level of management.

It must be noted that Katz's classification of management skills is widely used even today. This classification will also be used in this research paper.

Technical skills can be defined as a manager's ability to use the instruments, procedures and techniques in a specific field. It can be said that it is the most used skill by most people that is more concrete than other skills. Such skills are crucial to operations managers, but can also be used by middle- and top-level managers. Even though its relevancy diminishes as the level of management increases, such skills can be employed by middle-level managers in the finance, human resources, marketing, IT and law sectors. Top-level managers can use the skills in order to become familiar with the industry in which they operate as well as to understand the processes, procedures and products of their organization. Technical skills are essential in industrial development. They are also important as they help operational managers be effective and solve problems. Nevertheless, it must be noted that while they are crucial to low-level management they are nonessential to top-level management, because top-level managers can use human and conceptual skills in order to perform effectively (Katz, 1974; Yukl, 2006).

Interpersonal skills (human) are defined as a manager's ability to effectively work, by leading and motivating others. In contrast to technical skills, where one works with things, human skills focus on work with people.

Therefore, it is crucial that a manager has great communication skills. These are crucial for performing successfully in every managerial position. However, it must be noted that interpersonal skills are of greatest importance at levels where there is frequent contact between a manager and its employees. As levels of management increase, the frequency of contact between the manager and the employees decreases, the importance of interpersonal skills diminishes. Such skills are crucial to operational managers and middle-level managers and useful to top-level managers (Katz, 1974; Yukl, 2006).

However, the opposite happens with conceptual skills; the higher the managerial position, the more important conceptual skills become.

Conceptual skills are defined as the ability of a manager to look at the organization as whole. A manager must know how the functions of the organization are intertwined and be aware of the effects if something is changed (Katz, 1974). Conceptual skills are the proper skills for analyzing, diagnosticating and solving complex situations. These skills help a manager to understand how different components in the organization are connected, and how they influence a manager's decision-making and strategic planning. The success of decision-making depends on the conceptual skills of the top-level manager. Thus, the success or failure in decision-making resides with the manager. Studies have shown that conceptual skills are the most crucial to top-level management. Conceptual skills are not important in low-level management, but are important to middle-level management and extremely important to top-level(Northouse, 2010). Yukl (2006) said that although these are crucial to top-level management, nonetheless, they ought to be cultivated at the other levels of management.

A manager must be efficient and effective. Efficiency is defined as the correct performance of duties and can be measured as the ratio between the output and input. The focus on efficiency is in the time of performing tasks. A manager becomes more efficient if the ratio increases. This can be achieved in two as following: i) using in the same manner the resources, increasing the output, hence increasing the ratio and, ii) output remaining the same, but less resources are employed, and as a result the ratio increases.

Thus, management aims to reduce costs.

Effectiveness refers to performing the proper duties. The focus on effectiveness is in the goal. A manager aims at reaching the goals of the organization (Robbins and DeCenzo, 2008). Even though they are two different concepts, they are intertwined. A manager can be efficient but not effective or vice versa. It is best to be efficient and effective at the same time.

3. RESEARCH HYPOTHESES AND CONCEPTUAL MODEL

Research question:

How do management skills influence a manager's efficiency and effectiveness at different levels of management?

Main hypothesis: There exists a correlation between management skills and a manager's efficiency and effectiveness in accordance to the levels of management.

Other hypotheses regarding efficiency:

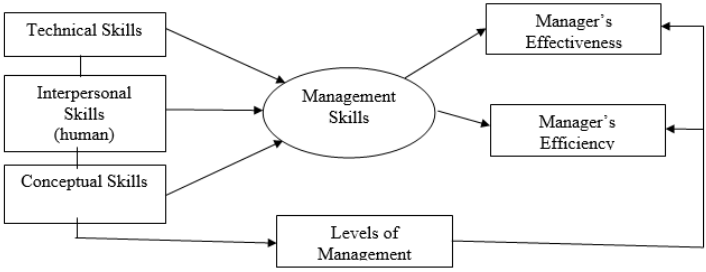
- H1a: There exists a correlation between conceptual skills and a manager's efficiency at the top-level management (α=0.05).
- H2a: There exists a correlation between conceptual skills and a manager's efficiency at the middle-level management (α=0.05).
- H3a: There exists a correlation between conceptual skills and a manager's efficiency at the low-level management (α=0.05).
- H4a: There exists a correlation between interpersonal skills (human) and a manager's efficiency at the top-level management (α=0.05).
- H5a: There exists a correlation between interpersonal (human) skills and a manager's efficiency at the middle-level management (α=0.05).
- H6a: There exists a correlation between interpersonal (human) skills and a manager's efficiency at the low-level management (α=0.05).
- H7a: There exists a correlation between technical skills and a manager's efficiency at the top-level management (α=0.05).
- H8a: There exists a correlation between technical skills and a manager's efficiency at the middle-level management (α=0.05).
- H9a: There exists a correlation between technical skills and a manager's efficiency at the low-level management (α=0.05).

Other hypotheses regarding effectiveness:

- H1b: There exists a correlation between conceptual skills and a manager's effectiveness at the top-level management (α=0.05).
- H2b: There exists a correlation between conceptual skills and a manager's effectiveness at the middle-level management (α=0.05).
- H3b: There exists a correlation between conceptual skills and a manager's effectiveness at the low-level management (α=0.05).
- H4b: There exists a correlation between interpersonal (human) skills and a manager's effectiveness at the top-level management (α=0.05).
- H5b: There exists a correlation between interpersonal (human) skills and a manager's effectiveness at the middle-level management (α=0.05).
- H6b: There exists a correlation between interpersonal (human) skills and a manager's effectiveness at the low-level management (α=0.05).

- H7b: There exists a correlation between technical skills and a manager's effectiveness at the top-level management (α=0.05).
- H8b: There exists a correlation between technical skills and a manager's effectiveness at the middle-level management (α=0.05).
- H9b: There exists a correlation between technical skills and a manager's effectiveness at the low-level management (α=0.05).

The conceptual model applied in this research paper is as follows:



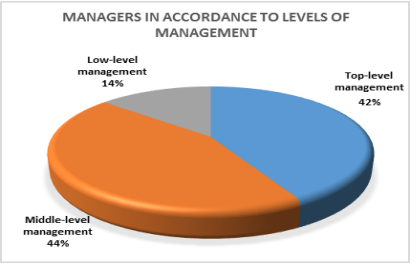
4. MATERIALS AND METHODS

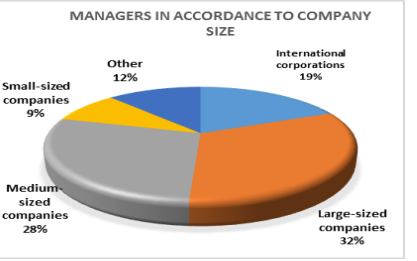
Quantitative research and descriptive analysis have been employed in the making of this research paper.

The instrument employed for research is the questionnaire Management Skills Assessment Instrument (MSAI), developed by Collett and Mora (1996). MSAI is used by the Management Program at the University of Michigan (Cameron and Quinn, 1999). This program was ranked in Business Week as one of the top-5 programs in the United States of America. Also, the questionnaire is used by Fortune 500 companies as well as companies in Europe, Asia and South America.

The questionnaire consists of 94 questions, including demographic questions. The responses are scaled through a five-point Likert scale ranging from "Strongly Disagree" or "Not At All Important" to "Strongly Agree" or "Extremely Important". The questionnaire scales three dimensions: management skills, a manager's efficiency and a manager's effectiveness. The first part of the questionnaire deals with management skills, the second part with the effectiveness of a manager, the third part with the efficiency of a manager and the fourth part includes demographic data. The questionnaire has been completed online.

The study sample consists of 115 managers in Albanian and international companies that operate in Albania. A total of 115 questionnaires were distributed, from which 102 were filled out and valid and 13 were incomplete. The response rate was 89%. The charts below show the distribution of managers in accordance to levels of management and size of organization.





For data analysis, SPSS 20 and JASP.0.8.0.1 has been used. For testing the correlations between variables Adjusted R^2 has been used.

The validity of the questionnaire was tested with the reliability coefficient Cronbach's Alpha. The table 1 report that the validity of the questionnaire trends high with alpha coefficient between the values 0.794 and 0.840.

Table 1. Reliability Coefficient Cronbach's Alpha

Variables	**Cronbach's α**
Technical Skills	0.800
Interpersonal Skills	0.794
Conceptual Skills	0.801
Manager's Effectiveness	0.825
Manager's Efficiency	0.817
Scale Reliability Statistics	
	Cronbach's α
scale	0.840

Note. Scale consists of items Technical Skills, Interpersonal Skills, Conceptual Skills, Manager's Effectiveness, Manager's Efficiency

5. EMPIRICAL ANALYSIS

Table 2 provides descriptive data into the study. The mean average ranges from 3.931 to 4.284. Interpersonal skills have the highest mean value 4.284. Standard deviation is analyzed as well; the values range from 0.5139 to 0.6176. The values of standard deviation show that the data are distributed about the mean average.

Table (2): Descriptive Statistics

	Technical Skills	Interpersonal Skills	Conceptual Skills	Manager's Effectiveness	Manager's Efficiency
Valid	102	102	102	102	102
Missing	0	0	0	0	0
Mean	4.206	4.284	4.196	3.931	3.961
Std. Deviation	0.5139	0.5336	0.5457	0.6176	0.5789
Minimum	3.000	3.000	3.000	2.000	2.000
Maximum	5.000	5.000	5.000	5.000	5.000

Table 3. Pearson's Correlations

		Manager's Effectiveness	Manager's Efficiency	Technical Skills	Interpersonal Skills	Conceptual Skills
Manager's Effectiveness	Pearson's r	—	0.602***	0.451***	**0.390*** **	0.452***
	p-value	—	< .001	< .001	< .001	< .001
	Upper 95% CI	—	0.713	0.593	0.544	0.594
	Lower 95% CI	—	0.461	0.281	0.212	0.282
Manager's Efficiency	Pearson's r		—	0.394***	0.517***	0.432***
	p-value		—	< .001	< .001	< .001
	Upper 95% CI		—	0.546	0.647	0.578
	Lower 95% CI		—	0.216	0.359	0.259
Technical Skills	Pearson's r			—	**0.687*** **	0.631***
	p-value			—	< .001	< .001
	Upper 95% CI			—	0.778	0.735
	Lower 95% CI			—	0.569	0.498
Interpersonal Skills	Pearson's r				—	0.623***
	p-value				—	< .001
	Upper 95% CI				—	0.729
	Lower 95% CI				—	0.487
Conceptual Skills	Pearson's r					—
	p-value					—
	Upper 95% CI					—
	Lower 95% CI					—

* p < .05, ** p < .01, *** p < .001

Based on Table 3, the correlation's highest value p <.001 (0.687) exists between technical skills and interpersonal skills. Whereas the correlation's lowest value p<.001 (0.390) exists between a manager's effectivity and interpersonal skills.

There exists a positive correlation p<0.001(0.631) between technical skills and conceptual skills. Also, there exists a positive correlation p<0.001 (0.623) between interpersonal skills and conceptual skills.

The most important correlation between management skills (independent variables) and a manager's effectiveness (dependent variable) with correlation coefficient p<0.001 (0.452) exists between conceptual skills and a manager's effectiveness.

The most important correlation between independent variables and a manager's efficiency with correlation coefficient p<0.001 (0.517) exists between interpersonal skills and manager's efficiency.Independent variables (management skills) have a positive impact on a manager's efficiency and effectiveness. It means that when management skills increase, so do the efficiency and effectiveness of a manager. Table 3 provides the answer to the main question.

Main hypothesis: There exists a correlation between management skills and a manager's efficiency and effectiveness in accordance to management levels. ***(α=0.05).***

Table 4. Results of the regression between management skills and a manager's efficiency

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.536	0.287	0.266	0.496	0.287	13.17	3	98	< .001

Table 4 conveys the correlation between management skills and a manager's efficiency. It is noted that Adjusted R^2 is 0.266. The results of regression analysis show that the three variables explain 26.6% of the variance, where Adjusted R^2 =0.266, F =13.17 and p<.001. Therefore, the regression analysis shows that there exists a positive correlation between management skills and a manager's efficiency.

In the table below is shown the effect each variable has in a manager's efficiency.

Table 5. Results of the regression between management skills and a manager's efficiency

Model		**Unstandar-dized β**	**Standard Error**	**Standardized Beta**	**t**	**P**
1	(Constant)	1.274	0.453		2.813	0.006
	Technical Skills	0.004	0.142	0.003	0.027	0.979
	Interpersonal Skills	0.438	0.135	0.404	3.242	0.002
	Conceptual Skills	0.189	0.124	0.178	1.528	0.130

Interpersonal skills have the greatest impact in a manager's efficiency with coefficient beta = 0.404, t=3.242 and p=0.002. The independent variable

maintains a positive direct correlation to a manager's efficiency. Conceptual skills have the correlation with the greatest impact, after interpersonal skills with coefficient beta=0.178, t=1.528 and p=0.130. Technical skills have the least impact of the three skills with coefficient beta = 0.003, t= 0.027 and p=0.979. It should be mentioned that all three variables have positive correlations with a manager's efficiency. It means that an increase in management skills directly influences an increase in a manager's efficiency.

Table 6. Results of the regression between management skills and a manager's effectiveness

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.501	0.251	0.228	0.543	0.251	10.96	3	98	< .001

Table 6 provides an analysis of the correlation between management skills and a manager's effectiveness. Adjusted R^2 is 0.228. An analysis of the results of the regression shows that all three variables explain 22.8% of the variance, where Adjusted R^2 =0.228, F =10.96 and p<.001. The regression analysis demonstrates the positive correlation between management skills and a manager's effectiveness.

Table 7 shows the measure of the impact of independent variables on a manager's effectiveness.

Table 7. Results of the regression between management skills and a manager's effectiveness

Model		**Unstandardized β**	**Standard Error**	**Standardized Beta**	**t**	**p**
1	(Constant)	1.161	0.495		2.346	0.021
	Technical Skills	0.295	0.155	0.246	1.906	0.060
	Interpersonal Skills	0.070	0.148	0.060	0.472	0.638
	Conceptual Skills	0.293	0.135	0.259	2.165	0.033

The table shows that conceptual skills a have the greatest effect on a manager's effectiveness with coefficient beta = 0.259, t=2.165 and p=0.033. It proves the existence of positive direct correlation with a manager's effectiveness. Technical skills follow with coefficient beta=0.246, t=1.906 and p=0.060. Interpersonal skills are last with coefficient beta = 0.060, t=0.472 and p=0.638. It can be argued from the above that there exists a

positive correlation with the manager's effectiveness, which means an increase of the independent variables increases a manager's effectiveness.

The main hypothesis is accepted with a reliability rate of 95%.

Top-level management

Table 8. Results of the regression between management skills and a manager's efficiency at the top-level management

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.559	0.312	0.259	0.514	0.312	5.906	3	39	0.002

Table 8 provides the results of regression analysis between management skills and a manager's efficiency at the top-level management. The data from the table shows that Adjusted R^2=0.259, which means that the independent variables (technical skills, interpersonal skills and conceptual skills) explain 25.9 % of the variance, with Adjusted R^2=0.259, F =5.906 and p=0.002. Table 9 provides information on the correlation of each variable to the efficiency of a manager at the top-level management.

H1a: There exists a correlation between conceptual skills and a manager's efficiency at the top-level management (α=0.05).

Conceptual skills are positively correlated to a manager's efficiency at the top-level management with coefficient beta=0.11, t= 0.052 and p=0.959. This brings to the conclusion that an increase of conceptual skills influences an increase of a manager's efficiency at the top-level management. The regression analysis concludes that H1a hypothesis is accepted with a reliability rate of 95%.

H4a: There exists a correlation between interpersonal (human) skills and a manager's efficiency at the top-level management (α=0.05).

In addition, it shows that interpersonal skills have the greatest impact on a manager's efficiency at the top-level management with coefficient beta=0.543, t= 2.730 and p=0.009. It means that there exists a positive correlation between interpersonal skills and a manager's efficiency. An increase in interpersonal skills results in an increase in a manager's efficiency at the top-level management. This shows that H4a hypothesis is accepted at a reliability rate of 95%.

H7a: There exists a correlation between technical skills and a manager's efficiency at the top-level management (α=0.05).

Table 9 shows that there exists a positive correlation between technical skills and a manager's efficiency at the top-level management with coefficient beta=0.012, t=0.058 and p=0.954. Technical skills influence a manager's

efficiency at the top-level management. H7a hypothesis is accepted at a reliability rate of 95%.

Table 9. Results of the regression between management skills and a manager's efficiency at the top-level management

Model		Unstandardized β	Standard Error	Standardized Beta	t	p
1	(Constant)	1.223	0.703		1.740	0.090
	Technical Skills	0.014	0.244	0.012	0.058	0.954
	Interpersonal Skills	0.630	0.231	0.543	2.730	0.009
	Conceptual Skills	0.010	0.199	0.011	0.052	0.959

Table 10. Results of the regression between management skills and a manager's effectiveness at the top-level management.

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.475	0.226	0.166	0.577	0.226	3.792	3	39	0.018

Table 10 shows that Adjusted R^2 =0.166. Regression analysis between independent variables and a manager's effectiveness concludes that independent variables explain 16.6% of the variance, where Adjusted R^2=0.166, F=3.792 and p=0.018. Table 11 provides an analysis in detail of each variable and a manager's effectiveness.

Table 11. Results of the regression between management skills and a manager's effectiveness at the top-level management

Model		Unstandardized β	Standard Error	Standardized Beta	t	p
1	(Constant)	1.516	0.790		1.920	0.062
	Technical Skills	0.484	0.274	0.394	1.767	0.085
	Interpersonal Skills	-0.021	0.259	-0.017	-0.080	0.936
	Conceptual Skills	0.119	0.223	0.118	0.535	0.596

H1b: There exists a correlation between conceptual skills and a manager's effectiveness at the top-level management (α=0.05).

Table 11 results of the regression show that conceptual skills are positively correlated to a manager's effectiveness at the top-level management with coefficient beta =0.118, t=0.535 and p=0.596. Conceptual skills influence a manager's effectiveness. H1b hypothesis is accepted at a reliability rate of 95%.

H4b: There exists a correlation between interpersonal (human) skills and a manager's effectiveness at the top-level management (α=0.05).

Interpersonal skills are negatively correlated to a manager's effectiveness with coefficient beta=-0.017, t=-0.080 and p=0.936. An increase in interpersonal skills does not have influence an increase in a manager's effectiveness. H4b hypothesis is accepted at a reliability rate of 95%, where interpersonal skills have a negative impact on a manager's effectiveness.

H7b: There exists a correlation between technical skills and a manager's effectiveness at the top-level management (α=0.05).

Table 11 shows a positive correlation between technical skills and a manager's effectiveness with coefficient beta=0.394, t=1.767 and p=0.085. Technical skills have the greatest impact on a manager's effectiveness. H7b hypothesis is accepted as a result of the analysis at a reliability rate of 95%.

Middle-level management

Table 12. Results of the regression between management skills and a manager's efficiency at the middle-level management

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.560	0.314	0.264	0.489	0.314	6.256	12	41	0.001

It can be seen that Adjusted R^2 = 0.264. Regression analysis shows that independent variables explain 26.4% of the variance, where Adjusted R^2 =0.264, F=6.256 and p=0.001. In the table below there is information on the impact of each independent variable in a manager's efficiency.

Table 13. Results of the regression between management skills and a manager's efficiency at the middle-level management

Model		**Unstandardized β**	**Standard Error**	**Standardized Beta**	**t**	**p**
1	(Constant)	1.584	0.773		2.049	0.047
	Technical Skills	-0.273	0.188	-0.247	-1.450	0.155
	Interpersonal Skills	0.516	0.179	0.488	2.881	0.006
	Conceptual Skills	0.373	0.194	0.299	1.920	0.062

H2a: There exists a correlation between conceptual skills and a manager's efficiency at the middle-level management (α=0.05).

Table 13 shows that conceptual skills are positively correlated to a manager's efficiency at the middle-level management with coefficient beta=0.299, t=1.920 and p=0.062. The analysis concludes that conceptual

skills have the greatest impact on a manager's efficiency. H2a hypothesis is accepted at a reliability rate of 95%.

H5a: There exists a correlation between interpersonal (human) skills and a manager's efficiency at the middle-level management (α=0.05).

The correlation between interpersonal skills and a manager's efficiency has the greatest impact with coefficient beta=0.488, t=2.881 and p=0.006. It means that interpersonal skills have the greatest impact on a manager's efficiency at the middle-level management. As a result of the analysis, H5a hypothesis is accepted at a reliability rate of 95%.

H8a: There exists a correlation between technical skills and a manager's efficiency at the middle-level management (α=0.05).

Technical skills are negatively correlated to a manager's efficiency at the middle-level management with a coefficient beta=-0.247, t=-1.450 and p=0.155. An increase in technical skills does not lead to an increase in a manager's efficiency. H8a hypothesis is accepted at a reliability rate of 95%.

Table 14 shows the results of the regression analysis between management skills and a manager's effectiveness. It can be seen that Adjusted R^2 is 0.204. This means that management skills explain 20.4% of the variance, where Adjusted R^2=0.204, F=4.752 and p=0.006. Table 15 provides a measure of the impact each independent variable has on a manager's effectiveness.

Table 14. Results of the regression between management skills and a manager's effectiveness at the middle-level management

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.508	0.258	0.204	0.497	0.258	4.752	3	41	0.006

Table 15. Results of the regression between management skills and a manager's effectiveness at the middle-level management

Model		**Unstandardized β**	**Standard Error**	**Standardized Beta**	**t**	**p**
1	(Constant)	1.282	0.785		1.633	0.110
	Technical Skills	-0.036	0.191	-0.033	-0.189	0.851
	Interpersonal Skills	0.260	0.182	0.252	1.430	0.160
	Conceptual Skills	0.433	0.197	0.356	2.193	0.034

H2b: There exists a correlation between conceptual skills and a manager's effectiveness at the middle-level management (α=0.05).

The correlation with the greatest impact is between conceptual skills and a manager's effectiveness with coefficient beta=0.356, t=2.193 and p=0.034. An increase in conceptual skills leads to an increase in a manager's

effectiveness at the middle-level management. H2b hypothesis is accepted at a reliability rate of 95%.

H5b: There exists a correlation between interpersonal (human) skills and a manager's effectiveness at the middle-level management (α=0.05).

Table 15 shows that conceptual skills are very importantly positively correlated to a manager's effectiveness with coefficient beta=0.252, t=1.430 and p=0.160. The analysis demonstrates that interpersonal skills have a positive impact on increasing a manager's effectiveness at the middle-level management. H5b hypothesis is accepted at a reliability rate of 95%.

H8b: There exists a correlation between technical skills and a manager's effectiveness at the middle-level management (α=0.05).

Based on Table 15 data, technical skills are negatively correlated to a manager's effectiveness at the middle-level management with coefficient beta=-0.033, t=-0.189 and p=0.851. Technical skills influence negatively a manager's effectiveness: an increase in skills does not increase a manager's effectiveness. H8b hypothesis is accepted at a reliability rate of 95%.

Low-level management

Table 16. Results of the regression between management skills and a manager's efficiency at the low-level management.

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.670	0.449	0.284	0.572	0.449	2.717	3	10	0.101

Regression results in Table 16 provide Adjusted R^2=0.284. The three independent variables explain 28.4% of the variance, where Adjusted R^2=0.284, F=2.717 and p=0.101. It means that independent variables are directly correlated to the dependent variables. Table 17 shows a more detailed view of this conclusion.

Table 17. Results of the regression between management skills and a manager's efficiency at the low-level management

Model		**Unstandardized β**	**Standard Error**	**Standardized Beta**	**t**	**p**
1	(Constant)	0.100	1.378		0.073	0.944
	Technical Skills	0.843	0.670	0.592	1.258	0.237
	Interpersonal Skills	-0.400	0.809	-0.316	-0.494	0.632
	Conceptual Skills	0.486	0.596	0.416	0.815	0.434

H3a: There exists a correlation between conceptual skills and a manager's efficiency at the low-level management (α=0.05).

Conceptual skills are positively correlated to a manager's efficiency at the low-level management with coefficient beta=0.416, t=0.815 and p=0.434. Also, conceptual skills have a direct impact in the increase of a manager's efficiency at the low-level of management. H3a hypothesis is accepted at a reliability rate of 95%.

H6a: There exists a correlation between interpersonal (human) skills and a manager's efficiency at the low-level management (α=0.05).

Table 17 shows that interpersonal skills are negatively correlated to a manager's efficiency at the low-level management with coefficient beta=-0.316, t=-0.494 and p=0.632. An increase of interpersonal skills does not influence an increase in a manager's efficiency at the low-level management. H6a hypothesis is accepted at a reliability rate of 95%.

H9a: There exists a correlation between technical skills and a manager's efficiency at the low-level management (α=0.05).

The most important correlation can be found between technical skills and a manager's efficiency with coefficient beta=0.592, t=1.285 and p=0.237. Technical skills have the greatest impact on a manager's efficiency. H9a hypothesis is accepted at a reliability rate of 95%.

Table 18. Results of the regression between management skills and a manager's effectiveness at the low-level management

Variable	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
Management Skills	0.662	0.438	0.269	0.447	0.438	2.598	3	10	0.110

Table 18 shows Adjusted R^2=0.269. Management skills explain 26.9% of the variance, where Adjusted R^2=0.269, F=2.598 and p=0.110. Management skills have the greatest impact on a manager's effectiveness at the low-level management. Table 19 provides regression data for each variable.

Table 19. Results of the regression between management skills and a manager's effectiveness at the low-level management

Model		**Unstandardized β**	**Standard Error**	**Standardized Beta**	**t**	**p**
1	(Constant)	1.580	1.077		1.467	0.173
	Technical Skills	0.251	0.524	0.228	0.480	0.642
	Interpersonal Skills	-0.800	0.633	-0.817	-1.265	0.235
	Conceptual Skills	1.023	0.466	1.132	2.195	0.053

H3b: There exists a correlation between conceptual skills and a manager's effectiveness at the low-level management (α=0.05).

Conceptual skills have the greatest impact on a manager's effectiveness at the low-level management. There exists a positive correlation between them with coefficient beta=1.132, t=2.195 and p=0.053. Their impact on a manager's effectiveness is great. H3b hypothesis is accepted at a reliability rate of 95%.

H6b: There exists a correlation between interpersonal (human) skills and a manager's effectiveness at the low-level management (α=0.05).

There exists a negative correlation between interpersonal skills and a manager's effectiveness with coefficient beta=-0.817, t=-1.265 and p=0.235. Interpersonal skills do not influence a manager's effectiveness, an increase in skills does not increase a manager's effectiveness. H6b hypothesis is accepted at a reliability rate of 95%.

H9b: There exists a correlation between technical skills and a manager's effectiveness at the low-level management (α=0.05).

Technical skills have a positive correlation to a manager's effectiveness with a coefficient beta=0.228, t=0.480 and p=0.642. Analysis concludes that technical skills have direct influence to a manager's effectiveness. H9b hypothesis is accepted at a reliability rate of 95%.

6. CONCLUSIONS AND RECOMMENDATIONS

Management skills are correlated positively to a manager's efficiency, where Adjusted R^2 =0.266. Interpersonal skills have the greatest impact on a manager's efficiency (coefficient beta =0.404). Management skills are correlated positively to a manager's effectiveness, where Adjusted R^2=0.228. Conceptual skills have the greatest impact on a manager's effectivity (coefficient beta =0.259). Of the independent variables, the strongest correlation exists between technical skills and interpersonal skills.

At the top-level management, interpersonal skills have the strongest correlation with a manager's efficiency with coefficient beta=0.543 and conceptual skills have the greatest impact on a manager's effectiveness with coefficient beta = 0.118.

At the middle-level management the greatest impact on a manager's efficiency is caused by interpersonal skills with coefficient beta=0.488, while on a manager's effectiveness, conceptual skills have the greatest impact with coefficient beta=0.356.

At the low-level management, technical skills have the greatest impact on a manager's efficiency with coefficient beta=0.592, while conceptual skills influence a manager's effectiveness with coefficient beta=1.132.

There exists a weak correlation between technical skills and a manager's efficiency and effectiveness at the middle-level management, which could be a result of varied perceptions related to work position, company size, or education and training. At the low-level management, interpersonal skills have a weak correlation to a manager's efficiency and effectivity, in contradiction to the existing literature.

Business organizations need to study the relationship between management skills and managerial efficiency and effectiveness through instruments analogous to the one presented in this study. The results of the study demonstrate the importance of training programs to improve interpersonal skills or "soft skills", especially for low- and middle-management. Attention must be paid to the organizational structure, by aiming to make task allocation more consistent and systematic and job descriptions coherent and concise.

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A STATISTICAL ASSESSMENT OF THE EARTHQUAKE ACTIVITYIN THE VLORA-LUSHNJA-ELBASANI-DIBRA TRANSVERSAL FAULT ZONE, ALBANIA

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ABSTRACT

In thepresent paper, a few seismotectonic parameters have been used for the statistical analysis of the seismic activity and assessment of the earthquake hazard potential along the Vlora- Lushnja-Elbasani-Dibra (V-L-E-D) transversal fault zone. There are a total of 2814 events in the time interval between 1964 and 2015 with $M_d \geq 1.7$. The correlation of seismotectonic*b*-value, fractal dimension *D*c-value, precursory quiescence *Z*-value, and theirinterrelationships with each other is here investigated. Anomalously low *b*-value areas coincide more or less with the spatial distribution of $M \geq 5.0$ earthquakes andtheir known rupture extents. The lowest *b*-values are centered at 40.83°N-20.03°E (in and around Kuçova),at 41.35°N-20.25°E (between Durrësi, Tirana and Bulqiza).Temporalchanges in *b*-value may be related to the stress variations in these times before and after the main events. Correlation dimension values are relatively large and the seismic activity is more clustered at larger scales in this transversal fault zone. The lowest *Z*-values show that the variations in seismic activity rate areinsignificant, and the highest *Z*-values demonstrate a decrease in seismicity rate. In the *Z*-value maps for all parts of the V-L-E-D, three areas exhibit significant seismic quiescence: centered at 41.00°N-19.78°E (region A, around Lushnja), 40.99°N-20.03°E (region B, in the Cerriku), 40.81°N-19.86°E (region C, including Kuçova). In addition to these three significant areas, there are some small quiescence areas in different parts of the V-L-E-D. Such kind of analyses of these can give important clues in order to reveal the earthquake hazard potential in the V-L-E-D and thus, special interest must be paid to these anomaly regions.

Keywords: Vlora-Lushnja-Elbasani-Dibrafault zone, earthquake activity, b-value,Dc-value, Z-value

1. INTRODUCTION

Albania is a seismically active area with tens of destructive large earthquakes over the past twenty centuries as revealed from the historical sources(Mogi, 1962;Polat, *et al*., 2008). The collision of Adria with the Albanian orogen is the source of the Albanian seismicity. This continental collision directly influences on the inner part of the country, on the longitudinal and transverse faults cutting across the eastern and north-eastern part of Albania (Aliaj, *et al*., 2001; Ormeni 2010). The Vlora-Lushnja-Elbasani-Dibra (V-L-E-D) Transversal Fault Zonein Albania is a major tectonicfeature with a well-defined fault trace and an established history of seismicity. Activity of the V-L-E-Dduring the 20th century began with the destructive Peshkopiaearthquake in 1920 in northeast Albania and migrated westwards by a series of destructive earthquakes in 1921, 1930, 1935, 1942, 1959, 1962, 1967, 1982, 2009, and 2014(Aliaj, *et al*., 2001; Ormeni 2010; 2012). The present investigation aims to analyze the spatial and temporal properties of seismicity pattern in the V-L-E-D Transversal Fault Zone in order to better understand the seismic hazards in this significant area. Consequently, theinvestigation addressed the mapping of size-scaling distributions (*e.g.*, spatial, temporal and magnitude distribution of seismic activity, completeness of magnitude, *Mc*, and *b*-values with time, fractal dimension, *Dc*-value, seismic quiescence *Z*-value) in the regional scale, and the correlation of results with the structural elements which carry high risk for the V-L-E-D region.

1. GEOLOGIC, TECTONIC / NEOTECTONIC SETTINGS OF ALBANIA

The main geological structures found within the Albanian territory are called the Albanides, which are part of the Dinaric-Albanid-Hellenic arc of the Alpine orogen. They are located between Helenides in the south and Dinarides in the north, which together form the Dinaric branch of the Mediterranean Alpine Belt. The V-L-E-Dtransversal fault zone (Ormeni 2012;Ormeni*et al*., 2013) (Fig. 1) with north-east strike dislocates the structure of the Albanides along their entire width. It is expressed by Vlora andLushnja flexure, Dumreadiapire dome, Elbasani Quaternary depression, Labinoti transversal structure, marked by important quaternary infill (Melo, 1986), Golloborda transversal horst continues toward the Tetova Quaternary graben in FYROM (Ormeni*et al*., 2013) (Fig. 1).

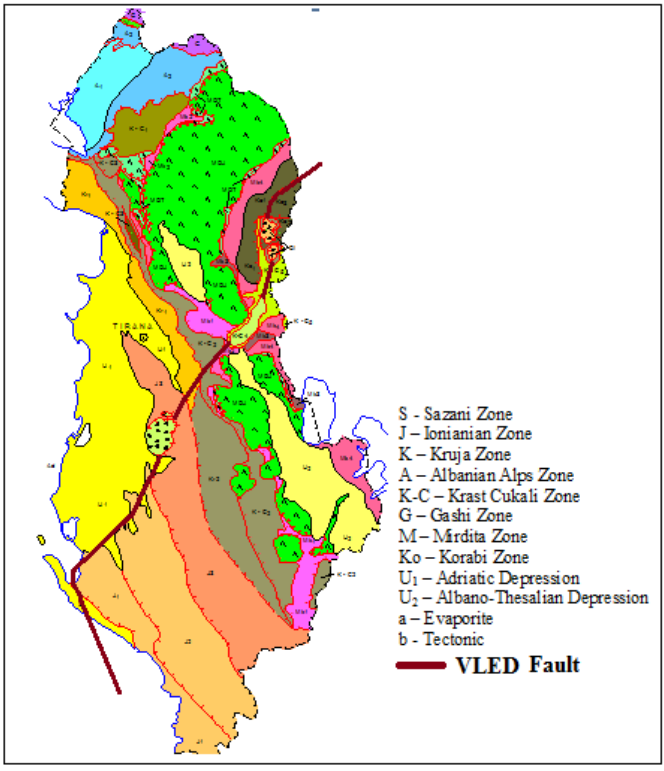


Fig. 1. Schematic tectonic map of Albania and seismic source zones in the VLED Transversal Fault Zone.

The region is both geologically and tectonically part of the Krasta tectonic subzone, which includes an area of Alpine folding. The Krastasubtectonic zone has been deformed by folds, normal faults, and strike-slip faults from movement of the main Alpine phases, which folded the aforementioned tectonic zone. Generally, the structures of the Krastasubtectonic zone extend N-S (Fig. 1). It must be emphasised that the investigated area of seismicity is located north of the Okshtuni tectonic window and south of the Dibra tectonic window. These tectonic windows are part of the V-L-E-D fault zone. This fault zone, NE trending for approximately 100 km in Albanian territory, consists of fragmentary normal faults cutting across the Krasta zone and dividing the Mirdita ophiolites zone in two main segments (Ormeni*et. al*., 2013)(Fig. 1). Based on the analysis of the focal mechanisms of moderate and strong earthquakes, the V-L-E-Dtransverse fault zone plays an important role in the seismotectonics of Albania, as well as of the FYROM(Aliaj, *et al*., 2001; Ormeni 2010).

The analysis of the focal mechanisms indicates the predominance of normal faulting with a strike-slip component, and the NNW-SSE extension in eastern Albania in response to the convergence between the Adriatic microplate and the Albanian orogen. The Vlora-Lushnja-Elbasani-Dibra fault zone has produced earthquakes in the past, and they are expected to continue to be active in the future. The studies in the past of moderate and strong earthquakes and their aftershocks have emphasised many geologic and seismotectonic characteristics of this area that constitute a threat for nearby urban areas of Vlora, Fieri, Berati, Lushnja, Elbasani, Librazhdi, Bulqizë and Dibra towns in Albania, and FYROM.

2. DATA AND DESCRIPTIONS OF THE METHODS

Figure 2 depicts the epicenter distributions of all earthquakes ($Md \geq 1.7$) and the principal main shocks ($Md \geq 4.5$). The focal depth analysis reveals that this seismicity was mainly generated in the shallow upper crust under tectonic conditions that were described earlier (Ormeni, 2012).TheV-L-E-Dhas experienced many damaging earthquakes during the past 95 years (Ormeni, 2010;2015). The Elbasani section has ruptured during earthquake occurred on 18 December 1920, (I=VIII degree), 31 March 1930 (*M* 5.7) and 19 May 2014 (*M*5.2). The Dibra earthquake of 30 November 1967 (*M* 6.7) is one of the greatest earthquakes that occurred in Albania.Here, other earthquakes 30 March 1921 Peshkopia (I=VIII-IX degree), 27 August 1942 Peshkopia (*M* 6.0), 6 September 2009 Gjorica (*M* 5.4)have occurred. The earthquakes have occurred 1 September 1959 Lushnja (*M* 6.2), 18 March 1962 Fieri (*M* 6.0), 16 November 1982 Fieri (*M* 5.4)in the Lushnja-Fieri section. The earthquakes that occurred in the Vlora segment are: 21 November 1930 Qaf-Llogaras (*M* 6.0).The behavior of seismic activity analyzed in this study is restricted to shallow events (<50 km). There are a total of 2814 events in the time interval 1964 and 2015 with $Md \geq 1.7$. In order to characterize the seismic behavior, a number of statistical parameters were used; namely size-scaling parameters (such as slope of recurrence curve *b*-value, fractal dimension *Dc*-value), temporal and spatial distribution of earthquakes with characteristics of seismic quiescence *Z*-value as well as the histograms of temporal, spatial and magnitude distribution along the V-L-E-D fault zone.

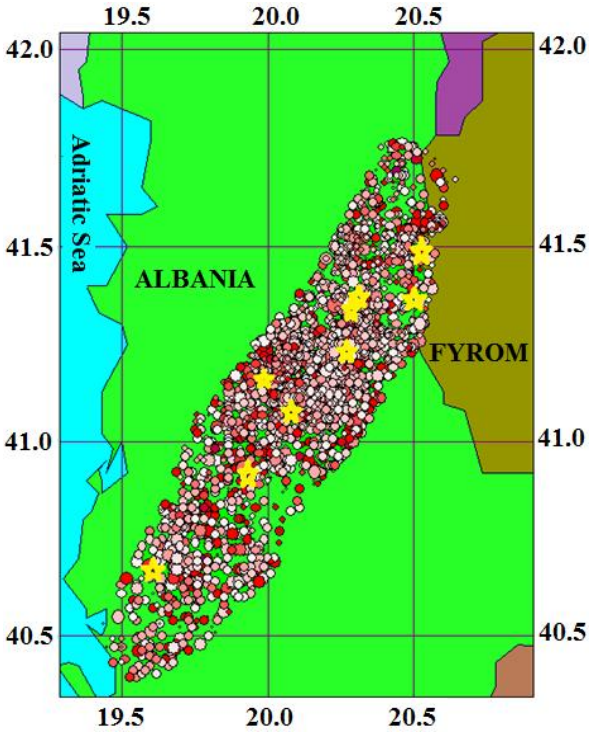


Fig. 2. Epicenter distributions of all earthquakes with Md≥1.7 and depth<70 km in the VLED Transversal Fault Zonebetween 1964 and 2015. Stars represent the principal main shocks with Md≥4.5.

3.1. Magnitude-frequency relation(*b*-value) and magnitude completeness, *Mc*

The relationship between the size of an earthquake and its frequency of occurrence named as Frequency magnitude distribution (Ormeni 2012) and defined as:

$$\log_{10}N(M) = a - bM \quad (1)$$

where $N(M)$ is the cumulative number of events with magnitudes equal to or larger than$M$. The parameters a and b are constants. The a-value shows the activity level of seismicity. The b-value is the slope of the frequency-magnitude distribution. The b-value has been shown to be inversely related to the shear stress in the crust (Wiemer and Wyss 2000). b-value is positively correlated with the increasing heterogeneity in the crustand shows (Özturk and Bayrak (2012)strong heterogeneity in finer scales. The b-value can be estimated from the maximum likelihood method (Aki, 1965):

$$b = 2.303 / (M_{mean} - M_{min} + 0.05) \quad (2)$$

where M_{mean} is the average value of magnitude and M_{min} is the minimum completeness magnitude in the seismicity catalogue to be analyzed. 0.05 value in this equation is a correction constant. The 95% confidence limits on the estimates of *b*-value are ±1.96 *b*/ *n*, where *n* is the number of events used to make estimation. The completeness magnitude, *Mc*, is an important parameter for many seismicity studies (Wiemer and Wyss 2000). In these studies, the usage of the maximum number of events available is necessary for high-quality results. Tendency of decreasing of *b*-values in temporal distributions before the large main shocks can be used as an indicator of the next earthquake (Özturk, 2011).Estimating of *Mc* can be made by the assumption of Gutenberg–Richter's power-law distribution against magnitude (Wiemer and Wyss 2000).

3.2. Fractal dimension, *Dc*

Earthquake distributions are considered fractal, but indirectly. Fractal distributions imply that the number of objects larger than a specified size has a power law dependence on the size. The fractal distributions are the only distributions that do not include a characteristic length scale, and therefore, are applicable to scale invariant phenomena. Spatial patterns of earthquake distribution and temporal patterns of occurrence are demonstrated to be fractal using the two-point correlation dimension, *Dc*. The correlation dimension measures the spacing or clustering properties of a set of points. The correlation integral method was developed byGrassberger and Procaccia(1983) and correlation dimension, *Dc*, is obtained from the following equations(Grassberger and Procaccia, 1983):

$$Dc = lim\ [log\ C(r) / log\ r] \quad (3)$$

$$C(r) = 2N_{R<r} / N(N-1) \quad (4)$$

where $C(r)$ is the correlation function, r is the distance between two epicenters or hypocenters, and N is the number of events pairs separated by a distance $R < r$. Fractal dimension is defined by fitting a straight line to a plot of log $C(r)$ against log r. Here r refers to the distance between each two hypocenters as stated in (Awad*et al*., 2005; Polat, 2008). The nature of temporal-spatial fractal properties of the earthquake epicenters is characterized by fractal, in particular by the correlation dimension (Wiemer 2001). Fractal dimension, *Dc*, can be calculated to avoid the possible unbroken sites, and these unbroken sites have been suggested as potential ***seismic gaps*** to be broken in the future and *Dc* is related to hypocentral

distance and to the physical models based on fluctuations in the elastic interactions between individual earthquake events (Toksöz*et al*., 1979). For the hypocenter distribution (3D space), the uniform distribution is in accordance with Eq. (4) and it decreases with an increase in the clustering of events (Awad*et al*., 2005). It is reasonable to assume that the higher *Dc* and lower *b*-values are the dominant structural feature in the study area and may arise due to clusters. It is also an indication of changes in stress (Polat, 2008).

3.3. Decomposing of catalogue and precursory quiescence *Z*-value

Some activities such as foreshocks, aftershocks, earthquake swarms, generally mask temporal variations of thenumber of events and the related analysis.The elimination of the dependent events from the catalogue is necessary for the reliable analysis of seismicity rate changes.In order to decompose(or decluster) the data based on the algorithm developed by Reasenberg(1985),*ZMAP* software in Wiemer(Wiemer 2001) is preferred.In study region, there are 2814 events with magnitudes greater than or equalto 1.7. *Mc* value for region is 2.5 and the number of earthquakes exceeding this completeness value is 1992. The decomposingprocess took away 460 events and 16% of the earthquakes were removed from the whole catalogue of region. Thus, the number ofevents for *Z*-value analysis was taken as 2354 for the VLED Fault Zone. In order to rank the significance of quiescence, the standard deviate *Z*-test is used(Wiemer and Wyss, 1994), generating the Log Term Average (LTA) function for the statistical evaluation of the confidence level in units of standard deviations:

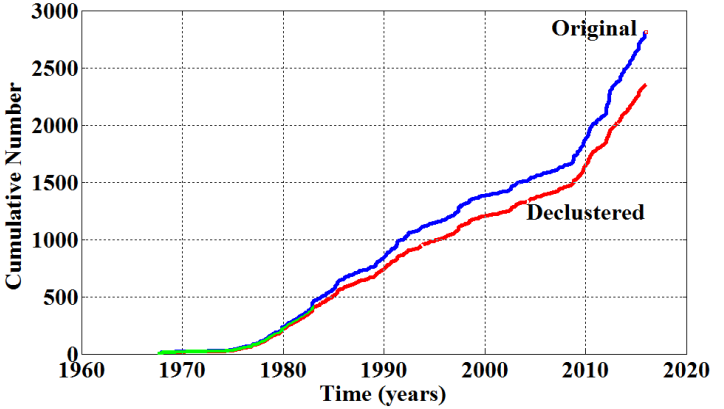
$$Z = (R1 - R2)\,(S1 / N1 + S2 / N2)^{1/2} \qquad (5)$$

where *R*2 is the mean seismicity rate in the foreground window, *R*1 is the average number of events in all background period, *S* and *N* are the standard deviations and the number of samples, within and outside the window. The *Z*-value calculated as a function of time, letting the foreground window slide along the time period of catalogue, is called LTA.

3. RESULTS OF SEISMICITY ANALYSIS AND DISCUSSION

A detailed investigation of the seismicity behavior in the V-L-E-D Transversal Fault Zone in Albania was carried out using the Gutenberg–Richter *b*-value, seismic activity rate changes, *Z*-value, fractal correlation dimension *Dc*-value and also by evaluating the histograms of the temporal, spatial and magnitude distribution in time intervals between 1964and 2015. As a result, this study is focused on the correlation of seismicity *b*-value, seismic quiescence *Z*-value, fractal dimension, *Dc*-value and

interrelationships between some other seismicity parameters. The cumulative number of earthquakes *versus* time in the region for original catalogue and for decomposed events is shown in Figure3. Asshown in Graph.1, there is no significant change of reporting as a function of time between 1964 and 1974 for region. But further on, great seismic changes are seen in this area, especially after 1980. Also, time-number histogram for between 1964 and 2015 indicate an increase in the number of recorded events in the year of 2012 (Chart. 1).Many stations have been constructed in recent years, especially after 2003 providing the real-time data with the modern on-line and dialup seismic stations and V-SAT stations in Albania.



Graph. 1. Cumulative number of earthquakesversus time for the original and decomposed events.

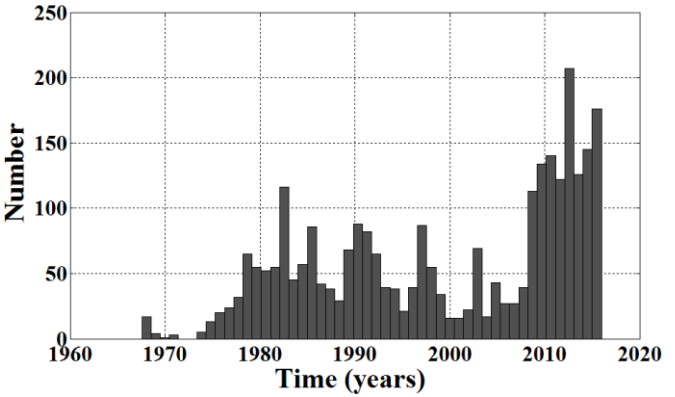


Chart.1. Time-number histogram for the seismic activity in study region.

Magnitude of earthquakes in this catalogue ranges from 1.7 to 6.7 with an exponential decay in their numbers from the lower to higher magnitudes. Graphic2 defines the magnitude-number histogram for the seismic activity of

region. Most of the earthquakes are between 2.0 and 3.5, and a maximum *Md*2.5 is observed (Chart2). In order to investigate the seismic quiescence and the frequency-magnitude relationship, the change of *Mc* as a function of time is determined using a moving window approach. *Mc* is estimated for samples of 50 events per window for region by using the earthquake catalogue containing all 2814 events of *Md*≥1.7. Figure 6 depicts the variations of *Mc* with time for all parts of the V-L-E-D. For this region, *Mc* value is rather large and varies from 3.0 to 4.0 between 1964 and 1979 while *Mc* decreases to about 2.5 between 1989 and 1993 (Fig. 6). Then, it decreases to about 2.4 in the beginning of 1998. However, there is a great value about 3.3. This large value is observed after the 2007 Kuturman compound earthquake sequence.Therefore, it can be said that *Mc* generally shows a non-stable value in the different parts of the V-L-E-D. However, it can be easily said that *Mc* value varies between 2.5 and 3.7 in the V-L-E-D. Using *ZMAP* software, the *b*-value in Gutenberg–Richter (Wiemer and Wyss, 2000)relation calculated by the maximum likelihood method, because it yields a more robust estimate than the least-square regression method (Aki 1965). Gutenberg–Richter (G-R) low describes the statistical behavior of seismic zones in energy domain using the frequency magnitude of earthquakes (Awad*et al.*, 2005).

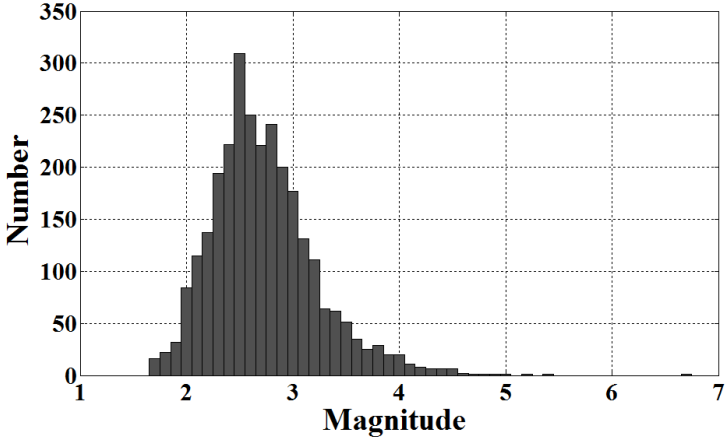
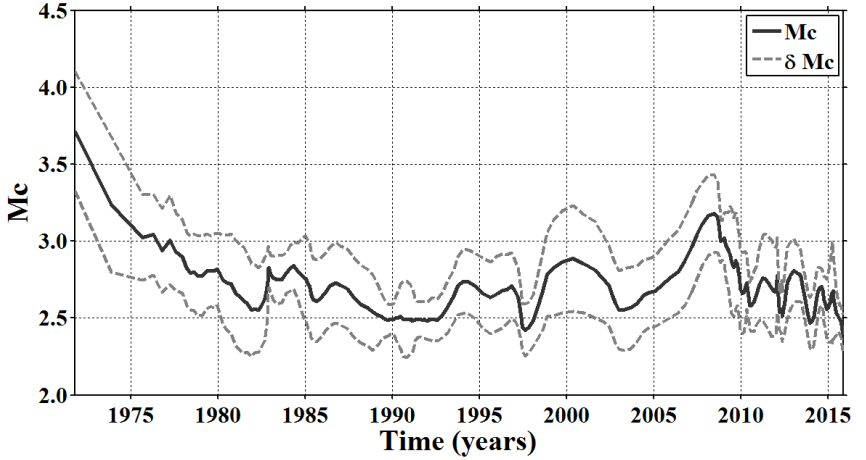


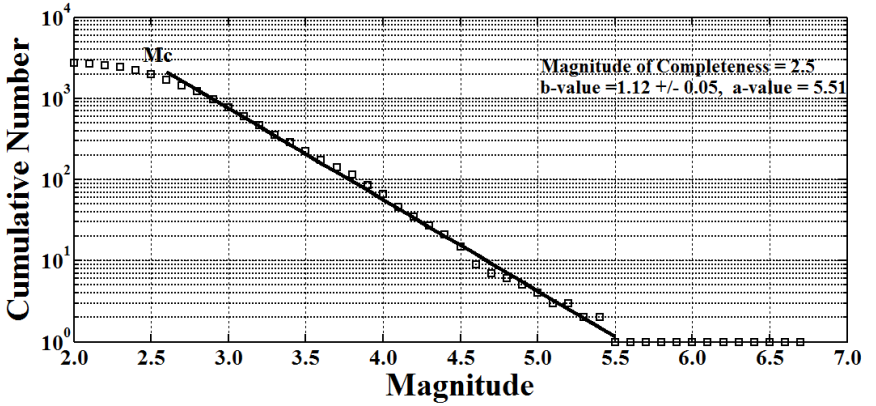
Chart. 2. Magnitude-number histogram for the seismic activity in study region.

Figure 7 shows the plots of cumulative number of the earthquakes against the magnitude for all parts of the V-L-E-D. The whole catalogue includes 2814 earthquakes (*Md*1.7) for epicentral depths less than 50 km. The *Mc*-value is calculated as 2.5 and using this value the *b*-value is calculated as 1.12 ± 0.05 and *a*-value 5.51 (Graphic3). The *b*-value and its standard deviation are determined with the maximum likelihood method, as well as the *a*-value of Gutenberg–Richter relation. The tectonic earthquakes are characterized by the

b-value from 0.6 to 1.5 and are more frequently around 0.9. It is clearly seen that the earthquake catalogue matches the general property of events such that magnitude-frequency distribution of the earthquakes is well represented by the Gutenberg–Richter law with a *b*-value typically close to 1.



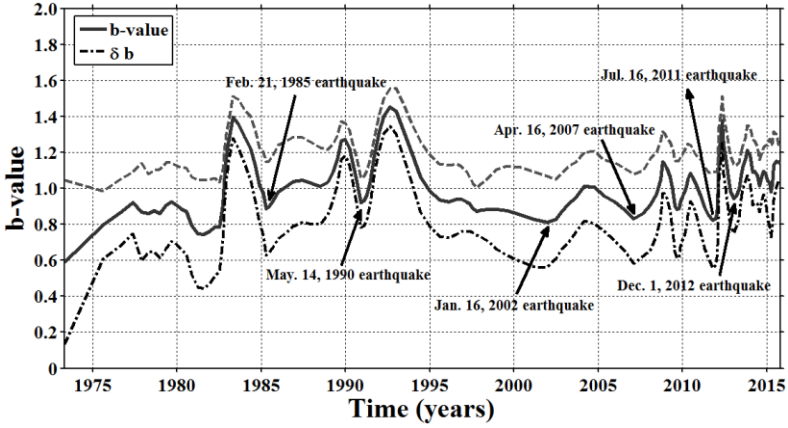
Graph. 2. Magnitude completeness, Mc, as a function of time. Standard deviation, δMc, of the completeness (dashed lines) is also shown. Mc value is calculated for overlapping samples, containing 50 events.



Graphic. 3. Magnitude-frequency-relation for all earthquakes between 1964 and 2015. The b-value and its standard deviation, as well as the a-value in the Gutenberg– Richter relation are calculated.

As depicted in Graphic4, the variation of the *b*-value as a function of time for the V-L-E-D Transversal Fault Zone is analyzed. A systematic increase in *b*-value can be observed until 1983 with $b>1.2$. The *b*-value shows a great decrease with $b\approx0.7$ before the occurrence of 1985 February 21 earthquake

and 1990 May 14 and a clear increase after the second main shock.Such a kind of behavior is also observed for some strong earthquakes in region(Ormeni 2012). There is a clear tendency of decrease with $b \approx 0.8$ before the 2007April16Kuturman compound earthquake and an increase with $b > 1.0$ after the main shock (Fig. 8). Many factorscan cause perturbations of the normal *b*-value. The *b*-value for a region does not reflect only the relative proportion of the number of large and small events in study area, but is also related to the stress condition over the region (Utsu, 1971). Therefore, it is considered that the anomalies of decreases in *b*-value before the main shocks may be due to an increase in effective stress and can be used as an indicator of the next earthquake by observing the changes in *b*-value with time in the study region. Also, temporal increase in *b*-value may be related to the stress changes in these times before and after the main shocks (Öztürk 2011; 2012). In the areas of increased complexity in the active fault system associated with lower *b*-value, the stress release occurs on fault planes of smaller surface area (Öncel and Wilson, 2000).



Graph. 4.b-value variations versus time. b-value wasestimated for overlapping samples of 75events. Standard deviation, δb, of the b-values (dashed lines) is also shown. Arrows show the great decrease in b-values before the strongevents in study region.

In addition to temporal changes of *b*-value, regional distribution of *b*-value for the V-L-E-d fault zone is mapped by using decomposed data with $Md \geq 2.5$. We used a regional grid of points with a cell of 0.02° in longitude and latitude (Fig. 3). The spatial variations of *b*-value vary roughly between 0.8 and 1.4. The largest *b*-values (>1.2) are located in and around Cërrik. The smallest *b*-values (<0.9) are observed at 40.83°N-20.03°E (in and around Kucova), at 41.35°N-20.25°E (between Bulqizë, Shëngjergj, Stebleve and Dibër).The moderate values changing between 0.9 and 1.2 are found in the other parts of the study region. Many authors stated that the site of the lowest b-value

mightbe the most likely place for a major earthquake (Awad*et al*., 2005; Polat*et. al*., 2008; Ormeni 2015). This could be explained with most promising environment where decrease in *b*-value is detected with an increase in mean stress. Similar results are also suggested by different authors for different parts of the world (Award *et al*., 2005; Öztürk 2011).

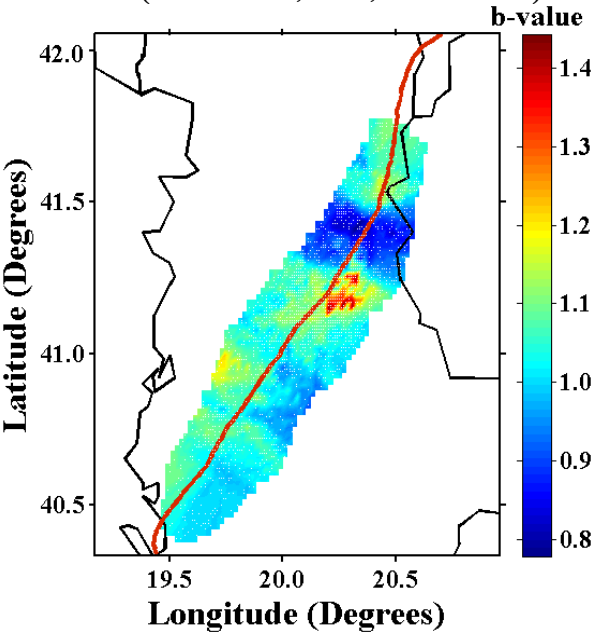
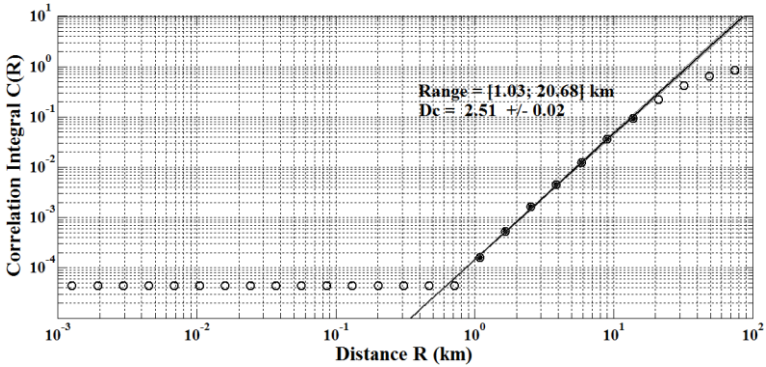


Fig.3. The map of b-value in VLED transversal fault zone estimated from the maximum likelihood method.

Correlation dimension, *Dc*, is estimated by fitting a straight (solid) line to the curve of mean correlation integral against the event distance, *R* (in km). The *Dc* values for the study area are obtained with 95% confidence limits by linear regression (Graph. 5). The earthquake distribution of 1841 earthquakes in the VLED Fault Zone is shown in Graph. 10. The correlation dimension, *Dc*, is calculated as 2.51 ± 0.02 for region. Correlation dimension, *Dc*, is estimated by fitting a straight (solid) line to the curve of mean correlation integral against the event distance, *R* (in km). The *Dc* values for the study area are obtained with 95% confidence limits by linear regression (Graph. 10).



Graph. 5. Correlation integral curves *versus* distance. Black dots represent the points in the scaling range.

The slope of the black line corresponds to the *Dc* value and the gray lines illustrate the standard errors.

Spatial distribution of the standard deviate *Z*-value for the V-L-E-D Transversal Fault Zone is presented for the beginning of 2010 (Fig. 4). Each *Z*-value is represented with different colors: the lowest *Z*-values are displayedwith blue and show that the change in seismicity rate is not significant, and the highest *Z*-values are represented with red and demonstrate a decrease in seismicity rate. Each *Z*-value in this representation is estimatedin correspondence of a different grid point. The computed *Z*-values are then contoured and mapped. To obtain a regional variation of the seismic quiescence mentioned earlier, the Reasenberg(1985) algorithm is applied to decompose the data. The areas under analysis were divided into rectangular cells spaced 0.02° in longitude and latitude. The nearest earthquakes, *N*, at each node are taken as 50 events after some preliminary tests for all regions and the seismicity rate changes are searched within the maximum radius changes by a moving time window, T_W(or i*wl*), stepping forward through the time series by a sampling interval asdescribed by Wiemerand Wyss (1994).

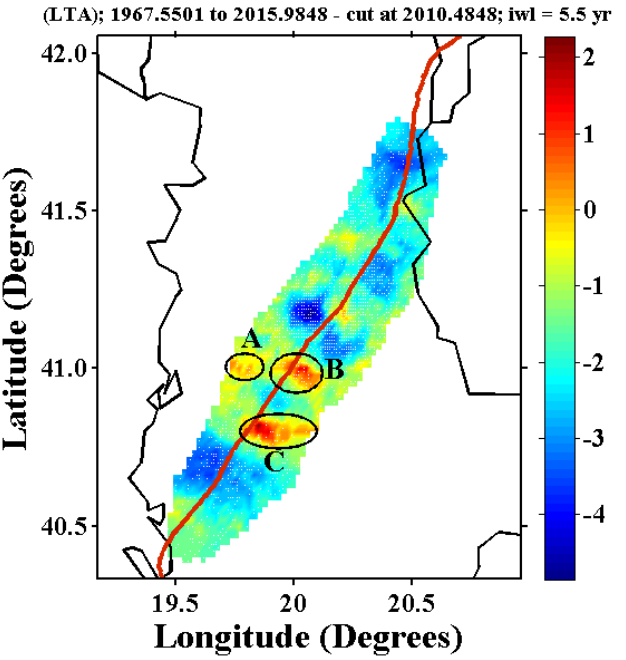


Fig. 4. Spatial distribution of Z-value in the beginning of 2010 with T_W(iwl) equal to 5.5 years. White dots show the decomposedevents.

The shape of the LTA function strongly depends on the choice of the length of the foreground window (*iwl*). While the statistical robustness of the LTA function increases with the size of *iwl*, its shape becomes more and more smooth, if the *iwl* length exceeds the duration of the anomaly. The time window, T_W, equal to 5.5 years is used. Since the quiescence anomalies obtained in Figure 3 are the best represented at the epicentral areas for T_W equal to 5.5 years, this time window length is used to image the spatial variation of the seismicity rate changes. For each grid point we binned the earthquake population into many binning spans of 28 days for all regions in order to have a continuous and dense coverage in time. The N and T_W values are generally selected accordingly to enhance the quiescence anomaly and this choice does not influence the results in any way. Figure 9 depicts the spatial variation of Z-values for region. The Figure 11 depicts the three areas (A, B, and C) exhibiting significant seismic quiescence. In addition to these three significant areas, there are some small quiescence areas. However, since these small quiescence areas are not very clear it is considered that they are not as significant as the other three quiescence areas. As a result, *Z*-value variation is represented in the beginning of 2010. Clear quiescence anomalies were identified at several seismogenic sources. In the *Z*-value maps for all parts of the V-L-E-D, three areas exhibit significant seismic quiescence. Covering the

V-L-E-D, the first significant quiescence is estimated centered at 41.00°N-19.78°E (region A, aroundLushnja) and the second one is estimated centered at 40.99°N-20.03°E (region B, in the Cërriku). The third significant anomaly is found centered at 40.81°N-19.86°E (region C, including Kuçova).

4. CONCLUSIONS

Temporal and regional assessments of the recent seismic activity are performed in order to put forth the seismic behavior in the V-L-E-DTransversal Fault Zone in Albania. So, a fewseismic parametersare used such as size-scaling parameters (such as slope of recurrencecurve *b*value), precursory quiescence *Z*-value, temporal and regional variationsof earthquakes with characteristic of fractal correlation dimension, *Dc*, aswell as the histograms of temporal, spatial and magnitude distributions. Forthis purpose, statistical analysis techniques based on the seismic tool *ZMAP*are used. The instrumental earthquake catalogues of ASN between 1964 and 2015 are compiled and finally2814 crustal earthquakes of magnitude equal and greater than 1.7, withdepths less than 70 km are obtained.Seismicity characteristics in the V-L-E-DTransversal Fault Zone show an important increase,especially after 2003. Analysis of completeness magnitude shows a valuebetween 2.7 and 2.9 for the V-L-E-D Transversal Fault Zone. *b*-value for studyis close to 1.0 and typical for earthquake catalogues. Temporal distributionsof *b*-values show a strong tendency of decreasing before the large mainshocks and this behavior can be used as an indicator of the future earthquake.The lowest b-values are centered at 40.83°N-20.03°E (in and around Kuçova), at 41.35°N-20.25°E (between Bulqizë, Shëngjergj, Stebleve and Dibër).Mapping of the *b*-values provides detailed images of the zones presenting low and high seismic activity and it may be used as a measure of seismic potential sources and relative hazard levels.Correlation dimension values are greater than 2.20 for all parts of the VLED. This suggests that seismic activity is more clustered at larger scales (or insmaller areas) in the VLED. Therefore, these higher values mean the dominant structural feature in the study area and may arise due to clusters. In order to separate the dependent events, Reasenberg algorithm is usedto separate the dependent events and the earthquake catalogue isdecomposed for the standarddeviate *Z*-value estimation. Importance of seismicity changes ismeasured at the nodes of a 0.02° grid space in longitude and latitude for the V-L-E-D Transversal Fault Zone. There are threeregions exhibiting significant quiescenceanomaly on the V-L-E-DTransversal Fault Zone in the beginning of 2010. These three anomalies are observed centered at 41.00°N-19.78°E (region A, around Lushnja), 40.99°N-20.03°E (region B, in the Cërriku), 40.81°N-19.86°E (region C, including Kuçova). These areas of seismic quiescence recently

observed, whichstarted at the beginning of 2010 in three aforementioned regions, can be consideredas the most significant. The V-L-E-DTransversal Fault Zone was struck with strong earthquakes in recent years.Therefore, spatial and regional prediction of the nextstrong earthquake in the V-L-E-D Transversal Fault Zone would beuseful.

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GEOTHERMAL ENERGY USE FOR SPACE HEATING AND COOLING IN ALBANIA AND THE EROPEAN UNION DIRECTIVES

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ABSTRACT

A feasibility study about the shallow ground heat resources in Albania, and ways for direct use of this energy for space heating and cooling ishere reported. One of the sustainable energy technologies being considered is the ground source - heat pump system. Earth heat could be efficiently used for space heating and cooling using ground source heat exchanger system — borehole heat exchanger-geothermal heat pumps. In Albania, direct use of the ground heat by borehole heat exchanger-geothermal heat pump for space heating and cooling following the EU directives would be appropriate as energy cost could be reduced.
Keywords: renewable energy, space heating and cooling, Albania, EU Directives

1. INTRODUCTION

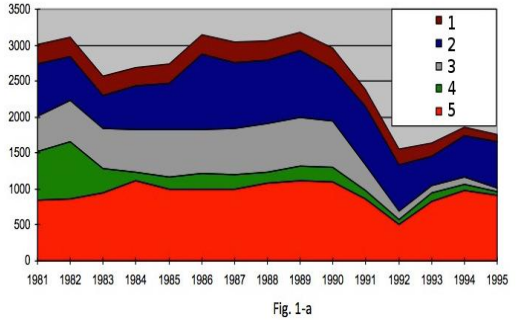
Different investigations have been made about geothermal energy of high and low enthalpy resources and thermal mineral water springs and wells in Albania which temperature goes up to 65.5℃. Given the importance geothermal energy and technological advances, economic development could be achieved. Considering the geothermal situation of low enthalpy in Albania, space heating and cooling, and integrated and cascade use of geothermal waters energy would be appropriate (Frashëri *et al*., 2009a- d; Frashëri *et al*., 2013, Eftimi and Frashëri 2016; Frashëri2016).

Direct use of the ground heat by borehole heat exchanger-geothermal heat pump represents a modern system for space (buildings and greenhouses) heating and cooling. The EU Directives for geothermal energy are of irreplaceable importance for an accurate use of geothermal energy (European Geothermal Energy Council – EGEC 2016; rch-platform.org, 2009; EGEC

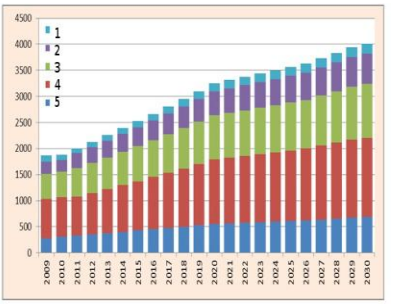
Geothermal Heating and Cooling Action Plan for Europe (http://www eroc-renewables.org/). European Geothermal Energy Council (EGEC) launched on April 15, 2009, the vision for 2030 for geothermal heating and cooling sector, presenting the contribution of the geothermal sector towards a 100 % renewable heating and cooling scenario in Europe. European Technology Platform for heating and coolingbrings together stakeholders from the biomass, geothermal and solar thermal sector - including the related industries - to define a common strategy for increasing the use of renewable energy technologies for heating and cooling.

2. Geothermal energy: current situation

Graphic 1a plots the energy sources in Albania and the graphic 1bplots the energy utilization by sector for the period from 2009 to 2030.



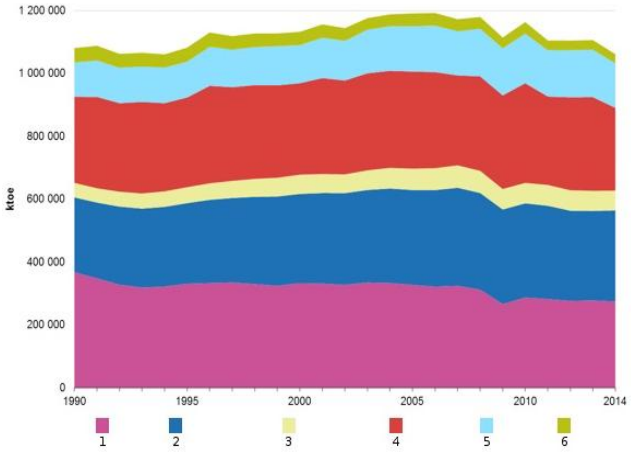
Graph. 1-a



Graph. 1-b

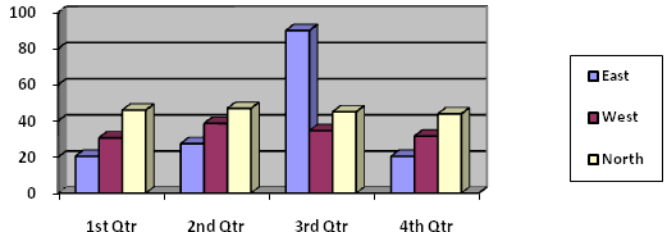
Graph. 1. Energy resources structure (1981-1995) (1-a)and byeconomic sectors (2009-2030) (1-b)[Ktoe]. (National Strategy of Energy–Albania).Graph. 1a: 1- Burning trees: - Hydro-energy: 3- Coal: 4- Natural gas: 5- Oil; Graph. 1b: 1- Agriculture: 2- Service: 3- Residential; 4- Transport: 5- Industry

Energy consumption by sector in the European countries is in the graph 2 plotted. In addition, both graphs plot ahigh residential energy consumption in Albania and EU countries, which tends to increase annually.

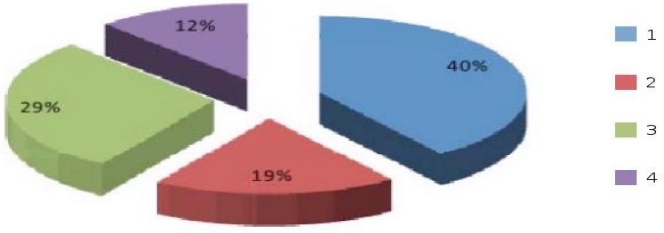


Graph. 2. Final energy consumption [Ktoe] by sector, EU-28, 1990-2014, (Eurostat Statistics Explained. webarchive) 1- Industry; 2- Road transport; 3- Other transport; 4- Residential; 5- Service; 6- Other.

Chart 3 shows the current distribution of electricity consumption in the residentialsector.



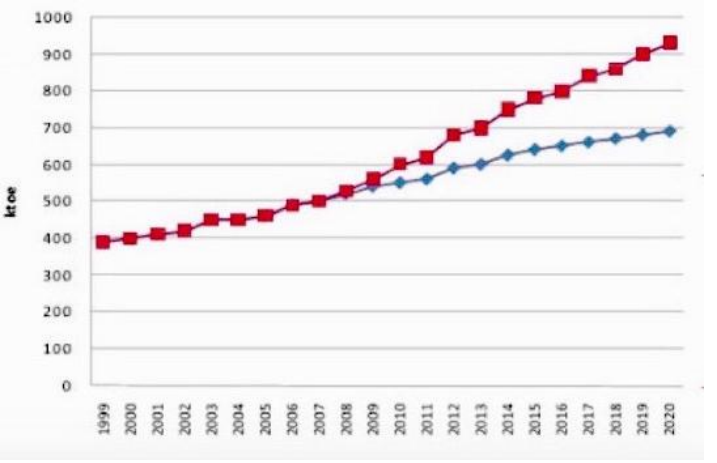
a)



b)

Chart. 3. The current distribution of electricity consumption in the residential sector of EU (Eurostat Statistics Explained, (a) Data from June 2016; file:/// Energy trends statistics explained web archive); (b) 1- Heating/cooling; 2- Lighting equipment; 3- Water heating: 4- Cooling.

Given the current situation of energy supply system and the demand for the energy supply, implementation of EU standards with regard would be crucial (Graph. 4).



Graph. 4. Forecast demand for energy in the residential sector (Eurostat: Statistics Explained, Data from June 2016: file:/// energy%20trends%20-%20Statistics%20Explained.webarchive) 1-Passive scenario; 2- Active scenario.

The current situation of the Albanian energetic supply system and the increased demand for new premises make new alternatives in energy supply of immediate importance. In 2003, the National Agency of Energy (2003), reported that Albania consumes annually an estimated of 375 GWh/ energy for heating purposes, or 23.8 % of the gross electricity production (Graph.1a,b). In addition to electricity, natural gas is used for domestic heating, emitting large quantities of CO_2 into the atmosphere.

Firewood heating has the higher costs.Given the importance geothermal energy and technological advances, economic development could be achieved. The Earth's heat is a great source of energy. Geothermal energy is part of the renewables energetic complex, which can be obtained from natural resources that can be constantly replenished. As the demand for alternative energy increases, the use of renewable energy becomes vital.Renewable energy technologies include technologies that use—or enable the use of—one or more renewable energy sources. Types of renewable energy technologies include: i) bioenergy, ii) geothermal energy, iii) hydropower, iv) ocean energy, v) solar energy and, vi) wind energy. Renewable energy otherwise

known as *renewables, green energy, and sustainable energy* is alow-cost energy from inexhaustible sources.

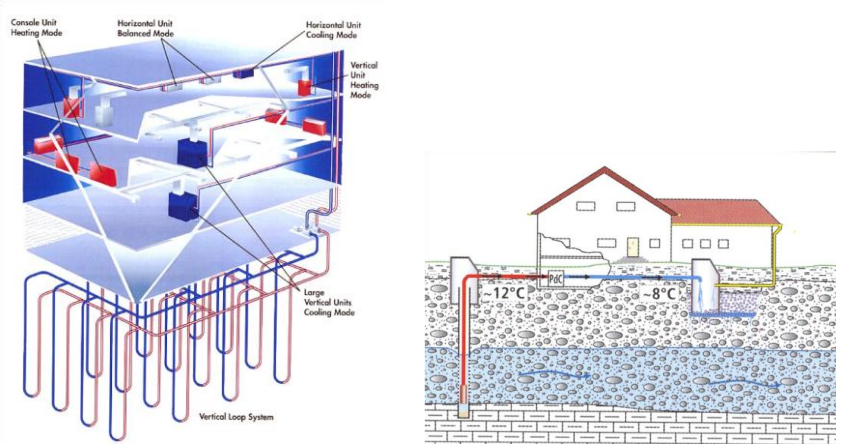
Modern geothermal technologies represent the integral and cascade using of Earth heat (Lund 1996; Rybach 2000). It is also used directly in many areas of life and economic activity. The table 1 reports the installed capacity and direct geothermal energy used worldwide-27.825 MWt and direct geothermal energy used is 261.418 TJ/yr, respectively (Lund *et al*., 2005).

Table 1. Installed capacity of geothermal energy used, and its structure

USE	**Instaled capacity (in MWt)**
Heat pumps for space heating and cooling SPA	56,6
Direct space heating	17,6
Greenhouses heating	14,9
Aquaculture	4,8
Industrial using	2,2
Cooking	1,8
Drying agricultural products	1,2
Etc.	0,6
	0,3
Total	**100,00**

Renewable energy is both of economic and environmental benefit. Exploitation of renewable energy doesnot create greenhouse gases and major impacts on the environment. Alternative energy might be successfully used for heating and cooling the public institutions and households.

Figure 1 (a) and (b) depict the two types of geothermal technologic schemes; *closed loop* and *open loop*, respectively (Lund, 1996; Rybach, *et al.*, 2000; Sanner, 2004; Curtis, *et al*., 2005; Rybach, 2005). Currently, these modern systems are highly effective due to the low consume of electric energy, and are environmentally friendly. The number of such installations is rapidly growing in the developed countries.



a) b)

Fig. 1. Borehole- Vertical Heat Exchanger- Geothermal Heat Pump System for space heating and cooling scheme, closet loop (a), open loop (b).

The number of BHE-HP installations (12 KW power each) has increased to over 570,000 worldwide. Today, the number of installations for large surface areas from 100 m^2 up to large blocks of households with total area to 161,650 m^2 is rapidly increasing. In 26 countries in Europe and the United States are built more installations; thousands more power installations 500-1500 KW heating institutions and municipal housing blocks have been used.

The number of geothermal heat pumps installations for space heating/cooling and its dynamic of implementation and use in Germany is in Graphic 6 plotted and Table 2-5 reported (after data from BWP).

Table 2. Target up to 2000 in Germany, [in Mtoe]

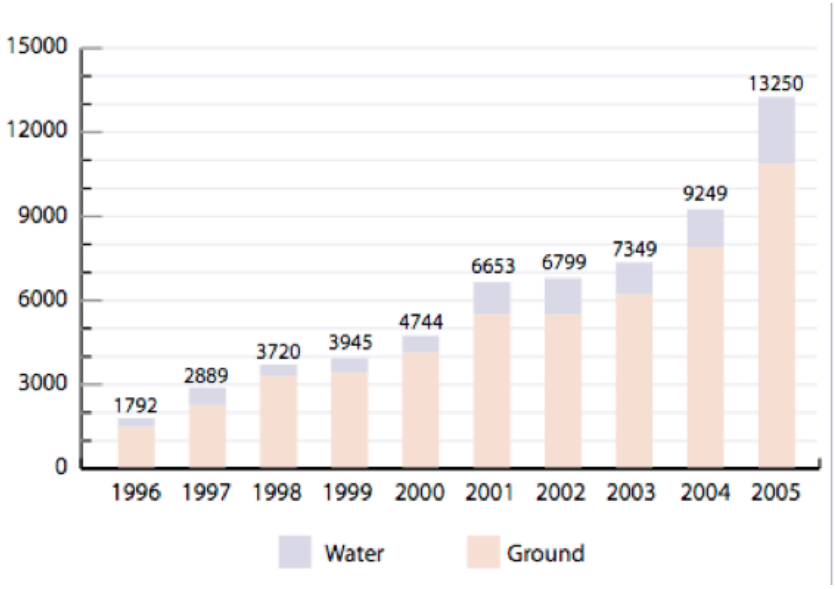
Geothermal Heating/Cooling	**1995 Eurostat**	**2000 Eurostat**	**2004 Eurostat**	**White Paper Target 2000**	**White Paper Target 2020**
White Paper Eurostat	0,56	0,66	1,5	2	
After projection EGECT			2005 2,1	4	8

Table 3. Installed and future potential in Germany, [in MW]

Geothermal Heating/Cooling	**2005**	**2010**	**2020**
White Paper Eurostat	8.500	1.000	
After Projection EGECT	EU 27: 8.750	16.000	39.000

Table4.Annual growth rates (AGR) up to now and expected until 2020 in Germany,[in %].

Geothermal Heating/Cooling	Real growth 1995-2001	Real growth 2001-2004	AGR 1995-2005	AGR 2001-2010	AGR 2010-2020
White Paper Eurostat	3,3	18		11,7	
After Projection EGECT			14,2	19,72	8,0



Graph. 6. Geothermal heat pump sales in Germany 1996-2005 (after data from BWP).

Albania has its own earth's heat energy coming from the subsurface ground layer which might be successfully used for heating and cooling the public institutions and households.

Performance coefficients (COP) are related to the type of pump—average value varying from 2,6 to 5,55.So, if 1 KW electrical energy is used involving the Earth's heat, 2,6-5,55 kW thermal energy could be obtainedfor space heating and cooling purposes and the cost reduced 6 folds, approximately. Consequently, EU bodies involved in the area consider this placed this technologyin top list of the technologies used for buildings and greenhouses heating purposes with different heaters in EU countries (Fig. 2).

	Best Available Technology (BAT) class for space heaters (including packages)
A+++	Packages using renewables
A++	Heat pumps (renewable) Best biomass boiler (renewable)
A+	Gas cogeneration
A	Condensing gas boilers
B	
C	Non-condensing gas boilers
D	Electric resistance

Fig. 2. Best Available Technology class for space heaters (European Commission. 2016).

All the state institutions involved in the area including scientific institutions have been informed about benefits of this technology (Frashëri 2002; 2009; 2011; 2013; 2015; 2016; Frashëri and Bushati 2005; 2007, Frashëri and Kodheli 2010; Frashëri *et al*., 2008a-d; 2013a, b) —by exemplifying the many plants with heat pumps constructed in several Albanian regionssuch as Erseka (1992), Tirana (1994) Shkodra, Korça etc., and yet this technology has not beenproperly implemented in Albania (Frashëri 2011).

Investing in such area would be beneficiary because effective use of renewable energy would be a source of social and economic development as new working places could be opened for the locals. In addition, environmental goals could be met.

3. Ground Geothermal Energy Resources in Albania

Heat quantity, soil temperature at Earth surface, and geothermal gradient in shallow geological section, are depend on geographical location, geomorphology conditions (Earth surface dip and position in relation to Sun), ground and bedrocks lithology, specific heat and humidity, season and weather. M*ultiannual meteorological*surveys report that the average ground heat from solar radiation is 140.000 calorie/cm^2 in summer at the plane areas of the Albania. Heat quantity goes up to 120.000 calorie/cm^2 at northeast mountainous regions (Gjoka, 1990).

Thermal field distribution and geothermal gradient values in the ground at shallow geological section depending on temperature variation at the depth 100m; from 16℃ to 18,8℃ at plane areas in the Ionian tectonic zone and the Peri-Adriatic Depression**.** The areas with a temperature between 18℃ and 19℃are located at Kolonjë-Divjakë-Kryevidh, Vlorë and Sarandë- Delvinë

zones. There are some particularities in the distribution of the temperature at the depth 100m (Frashëri *et al*., 2013a, b).

The temperature varies from-16, 60℃ to -18,80℃ in the subsurface ground of the littoral area and the mean temperature is -17,80℃. The temperature in subsurface ground at western plane-hilly area varies from 17,15℃ to 18,41℃ and the average temperature is 18,0℃. The temperature in subsurface ground at hilly mountains regions varies from 6, 70℃ to 18, 60℃ and the mean temperature is 14,75℃.

The temperature of the Tirana field (Rinasi) up to logging depth 31 m—the Quaternary deposits— is 15,5℃ (Frashëri *et al*., 2003). Investigations reported that the solar radiation energy is of great impact for the temperature at the depth varying between 0 and 10 m.In winter, the temperature is lower thansummer. Deeper than 10 m, the ground temperature is constant during the year, as there is no influence from solar radiation. The depth limit of the solar radiation influence zone is not unique. Lateral changes up to 0,5℃ are observed in the 500m distances, during the same time. The source is the lithological composition of the Quaternary loose deposits. The belt of the constant temperature continues up to the depth 50 m, in the mountain regions. The water temperature of the Quaternary sandstone layers varies between 14 to 15℃.

Ground geothermal energy has heated the underground water reservoir. The underground water basin, i.e., the water temperature of the Quaternary gravel layer in Tirana varies 14 to 15℃. Consequently, it could be used as heating source for the geothermal pumps.

Investigations regarding the geothermal regime of the shallow geological section reported that the ground heat for the space heating and cooling could be possible involving the Borehole Heat Exchanger – Geothermal Heat Pump.

4. Feasibility study on the use of plants with heat pumps for space heating/cooling in Albania

Frashëri and Kodhelaj (2010) and Frashëri (2016) have previously reported the results of the feasibility study for the use of plants with heat pumps for space heating/cooling by exemplifying the heating of a hotel in Tirana.

Total heated surface for the three floors was 610 m^2 and heating capacity 68.5 KW.The heating period lasted 1836 hours.

Figure 3 and 4 depict the operating cost for annual consumption of electric energy or fuel, and the total annual heating energy cost (Installed and operating cost) for 10 years, involving different heating systems (Frashëri, 2016).

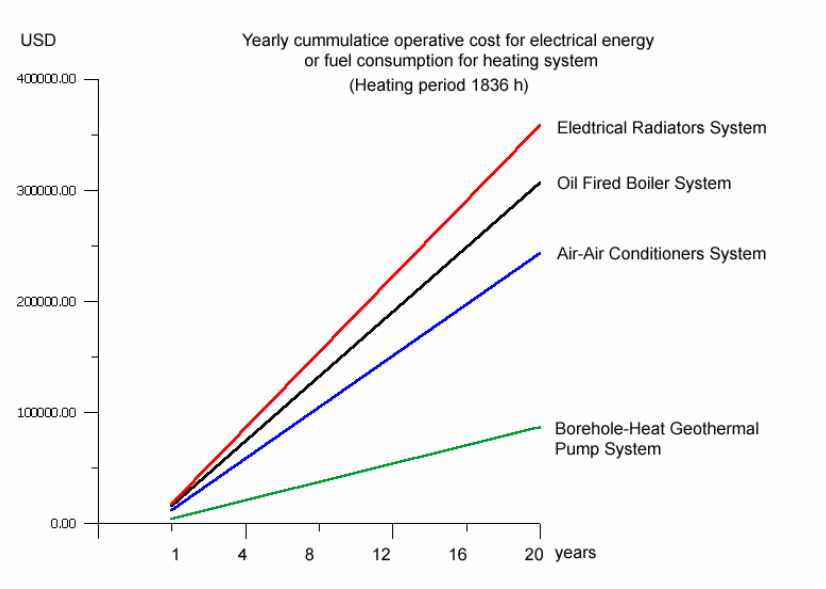


Fig. 3. Yearly cumulative cost for electrical energy or fuel consumption for heating system (Heating period 1836 h).

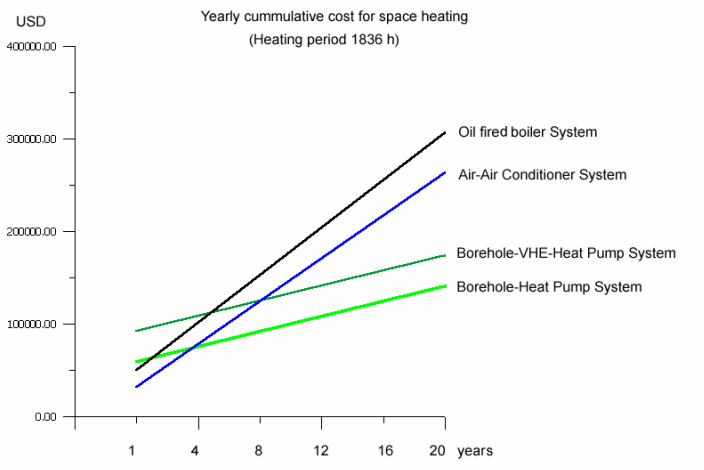


Fig. 4. Yearly cumulative cost for space heating (heating period 1836 h).

Installation cost for geothermal system unit is 83- 133 USD/m^2, and 744-1180 USD/kW, depending from the heat source, however. The borehole-vertical heat exchanger-geothermal heat pump system is more expensive than the borehole-geothermal heat pumps systems, with shallow underground water heat source.

Basing on figure 5 installation cost for the geothermal systems is 2.0-2.8 higher than the installation cost of boiler or air-air conditioner systems.

The payback periodfor the installed cost for the borehole-geothermal heat pump system is 2 years and covered only by expenses savings for boiler fuel, and 4 years, covered only by expenses savings for air-air conditioners.

The payback period is 4 years for the installed cost for the borehole-vertical heat exchanger-geothermal heat pump system, covered only by savings expenses for boiler fuel, and 8 years, covered only by savings expenses for air-air conditioners.

Chart 4shows that graphically that space heating and cooling involving different heating systems (in USD/kW). As it could be clearly noted, the geothermal heating and cooling system is a more economic system.

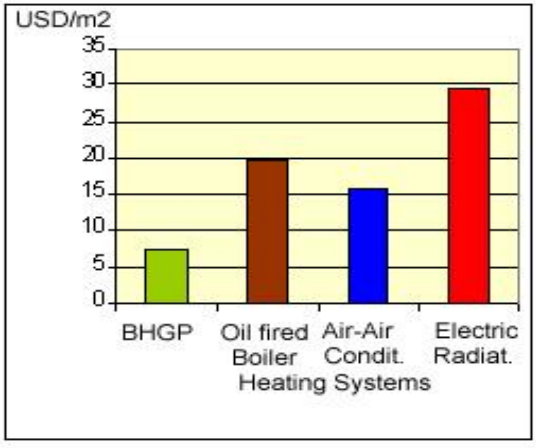


Chart. 4. Cost of space heating for different heating systems (in USD/m^2) (Frashëri 2016).1- Geothermal System; 2- Oil Fired Boiler System; 3- Air-Air Conditioner System; 4- Electric Radiator System.

There are many high buildings in Albania which use of oil - gas fired boiler systems, or air conditioning system. State institutions use air conditioning system; while hospitals, dorms and hotels use oil - gas fired boilers; none of them efficient. As heating and cooling systems have economic, social, environmental consequences, scientific solutions are vital and collaboration among the stakeholders is required. Given the current situation and the importance of renewable energy, investing in geothermal energy would be appropriate.

Japan for example using the geothermal energy of subsurface ground layers saves up to 40% of the total energy. The expenses necessary to carry out this project will be paid within 10 years. Two thirds of the building costs, valued

up to 10 million yen for the government and local authorities support each installation. The Japanese government has invested 200 USD for every kW of the Heat Geothermal Pump, with an upper limit of 5 200 USD.

5. CONCLUSIONS AND RECOMMENDATIONS

The current situation of the Albanian energetic supply system and the increased demand for new premises make new alternatives in energy supply of immediate importance.

Investing in such area would be beneficiary because effective use of renewable energy would be a source of social and economic development as new working places could be opened for the locals. In addition, environmental goals could be met.

The payback periodfor the installation cost for the borehole-geothermal heat pump system is 2 years and covered only by expenses savings for boiler fuel, and 4 years, covered only by expenses savings for air-air conditioners.

The payback period for the installation cost of the borehole-vertical heat exchanger-geothermal heat pump systemis 4 years, covered only by savings expenses for boiler fuel, and 8 years, covered only by savings expenses for air-air conditioners.

University, Fan Noli, in Korça, Albania is a good example of such economic benefit.

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THE MESSINIAN EVAPORITES OF THE PREADRIATIC FORELAND BASIN (ALBANIA)

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ABSTRACT

The stratigraphic succession of the Messinian Evaporites on the Preadriatic foreland basin (PAB) has been investigated and the data are here reported. The Kavaja section represents the most continuous and complete sequence of the Messinian succession from onset of Messinian salinity crisis up to Pliocene marine conditions and comprises two main evaporitic successions separated by an erosional surface (MES) with an angular unconformity. The lower succession starts with pre-evaporitic deposits (uppermost part of marine Tortonian (Mengaj Fm.) characterized by oligotypical foraminifer assemblage and extinction of molluscs, that suggesting a rapid change of environmental conditions prove the onset of the Messinian salinity crisis. The overlain lower gypsum consists of Gips-Sharrë gypsum (intercalations of marls and up to 9-12 selenite gypsum beds), and 16-30 m thick Salt (halite) accumulated during a high evaporation phase associated with erosional surface. The upper succession consists of thick marls intercalations with two 4 and 7 m thick selenite-gypsarenite beds of Mushnike gypsum and post-evaporitic very cyclic intercalations of marls and sandstones termed over gypsum marls with hypohaline benthic and marine planktic foraminifera. Upper boundary was placed in contact of this post-evaporite marls with overlying Pliocene (Zanclean) normal marine deposits. In the north and south of Kavaja region, in Durrës and Vlorë peripheral marginal sub-basins, respectively, Messinian evaporites are presented only by the lower succession cutting on the top by the erosional surface and overlies with slightly angular unconformity by the marine Pliocene deposits. The Messinian evaporites yield an oligotypical, dwarf planktonic and scarce mainly brackish benthic foraminifer's assemblage. Toward the south of the Kavaja region, to the north of Vlora, the Messinian Evaporites laterally pass in a thick siliciclastic unit recording a continental fluvial-deltaic facies.

Keywords: Messinian evaporites, Preadriatic foreland basin, stratigraphy

INTRODUCTION

The Messinian salinity crisis is one of the most dramatic episodes of environmental changes in the Mediterranean basin which resulted in the accumulation of evaporites into peripheral marginal shallow basins. The present paper provides accurate information about the integrated stratigraphy of the most continuous Messinian Evaporites from the pre-evaporitic marls to the ends of the Messinian with the post-evaporitic marls overlain by marine Pliocene deposits occurred in the Preadriatic foreland basin (PAB) (Fig.1). As it is the northernmost Messinian outcrops along the eastern side of the Adriatic Sea, they are of particular importance for the stratigraphic and regional correlations of the Mediterranean Messinian evaporites. The Miocene gypsum in Albania, were first described at the beginning of the 20th century" as thick gypsum deposits that mainly developed north of the Vlora region" (Martelli *et al*., 1910). The hydrocarbon and lignite exploration enhanced Albanian stratigraphy of the Miocene deposits during the second half of 20th century. During the first field studies, Miocene succession with gypsum bed in Kavaja area has been named as Upper Miocene (Murataj *et. al*., 1958) and ten years later the stratigraphic features of the Messinian deposits were investigated (Pashko *et. al*., 1969a).

Messinian deposits outcropping on PAB are part of the continuous Neogene sedimentary succession from Serravalian to the end of evaporitic Messinian, following by fully marine Pliocene deposits. The Messinian evaporites extend from Kepi i Rodonit in north up to the east of Rrogozhina. Towards the south, it undergoes an abrupt change in lithology grading to a thick siliciclastic continental series formed in a fluvial-deltaic setting, and outcrops again in Vlora area (Fig. 1). The six stratigraphic sections were accurately measured and studied during the stratigraphic investigation of the Tortonian-Messinian deposits of PAD (Pashko *et al*., 1969a). The best exposed and complete succession of Messinian evaporites was developed in the Kavaja region, whereas toward the Durrësi and Vlora region it is represented only by the lower gypsum unit cut on top by an erosional surface and overlies of marine Pliocene deposits with an angular discordance. The salt unit could be found in the Kavaja region up to 15-20 m in subsurface (Cocoli *et al*., 1989; 1992).

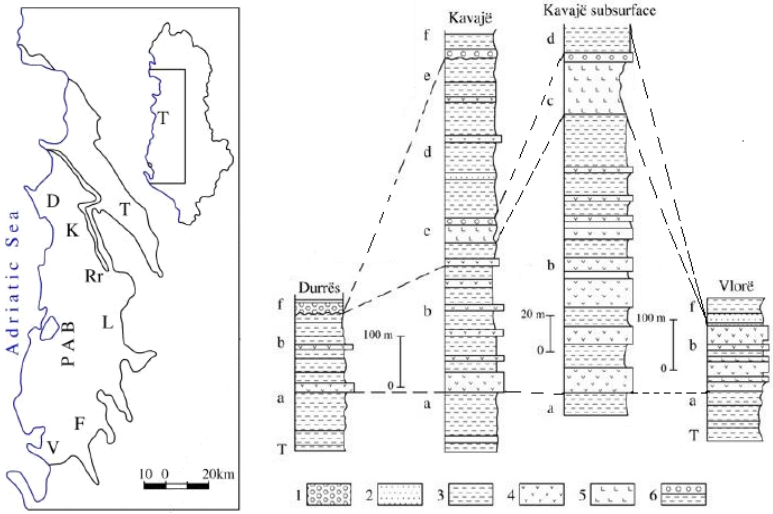


Fig. 1. Stratigraphical column of the studied sections: T - Tortonian, a -Under-Gypsum Marls, b - Gips-Sharrë Gypsum, c – Salt Unit, d - Mushnike Gypsum, e - Over-Gypsum Marls, f - Pliocene. 1.Conglomerates, 2. Sandstone, 3. Clays, Marls, 4. Gypsum, 5. Salt, 6. Unconformity; PAB – Preadriatic Basin, D - Durrës, K – Kavajë, Rr – Rrogozhinë, L – Lushnje, F - Fier, V – Vlorë, T - Tiranë.

Geological Setting

Messinian deposits were accumulated in PAB located in SE part of Adriatic Foredeep and spreads in the west of Alpine folding, between Shkodër-Pejë transversal fault and Vlorë-Tepelenë flexure. The complete basin sedimentary sequences consist of a thick Neogene marine succession dating from Middle Miocene (Serravallian) to the Pliocene, overlain by marine or continental Quaternary deposits. Miocene deposits constitute the eastern and southern margins of PAB, whereas those of Pliocene-Quaternary cover the most western parts of them. The Neogene sedimentary succession of the basin shows a gradual depth exchanges from shallow-water Serravalian transgressively on oldest basements, through relatively deeper Tortonian, Messinian evaporite and deeper Pliocene deposits. Serravalian sequence consists of basal conglomerate-sandstone series and thick lithothamnion limestone. Tortonian sequence is characterized mainly by thick massive sandstone and grey clays with Ostrea banks or mainly grey clays with thin sandstone and lithothamnium limestone layers rich in marine mostly molluscs and plankton foraminifers of and *Globigerinoides obliqus* and *Globorotalia*

menardi-4 Zones. Tortonian/Messinian boundary identified by the appearance of *Globorotalia conomiocea*, whereas the Messinian Evaporites are characterized by an "undetermined zone" (Prillo *et al*., 1992). The thick Pliocene deposits are transgressive on the oldest basements from neritic Cretaceous limestone of Kruja Zone to several formations of Miocene deposits. The six stratigraphic sections were accurately measured and studied during the stratigraphic investigation of the Tortonian-Messinian deposits of PAB (Pashko *et al.,* 1969ab; Pashko 1971). The best exposed Messinian succession was accumulated in a subsiding basin of Kavaja region and represent a most continuous succession from the onset of the Messinian Salinity Crisis up to basal marine Pliocene deposits. Like its equivalents of Caltanissetta basin in Sicily (Roveri *et al.,* 2008b) the Kavaja Messinian succession consists of two main evaporitic parts: the lower and upper evaporites separated by an erosional surface with slight angular unconformity. On the contrary, in the "marginal" Durrës and Vlorë basins the Messinian succession probably accumulated in different conditions and characterized by incomplete succession, which consists only of lower evaporites cut on top by an erosional surface. The present paper reviews the main results of the stratigraphic field and subsurface studies carried out in Kavaja section and other outcrops during Messinian Salinity Crisis (MSC) in PAB.

Photo. 1. The T/M boundary, Gips-Sharrë (Lower) Gypsum and Inter-Messinian unconformity of the Kavaja section

Stratigraphic features of Kavaja Section

More complete succession of the Messinian evaporites exposed in the Kavaja region and the outcroping and buried Messinian succession shows a Mediterranean evaporitic section. Based on the detailed data report that this succession consists of up to 750 m thick dominant blue-grayish clays intercalated with usually fine sandstone layers alternating with numerous

gypsum beds and associated with a salt horizon. Roveri *et al*., (2008a-c) said that the Messinian succession consists of two main evaporitic units separated by an erosional surface that has been subdivided from the bottom into following unit: pre-evaporite under gypsum marls, gyps-Sharrë gypsum and salt (Lower Evaporites) followed by Mushnike gypsum unit and post-evaporite over gypsum marls (Upper Evaporites) (Pashko *et al*., 1969ab; Pashko 1973).

Lower Evaporites

Figure1a depicts the Pre-Evaporite, Under Gypsum Marls (Mengaj Formation) This formation, up to 320 m thick, represent the pre-evaporite deposits (upper part of the Tortonian) below the first gypsum bed and consists dominantly of cyclic alternation of marine blue-grayish marls and more indurated grayish sandy marls of 10-20 centimeters thick, minor layers of yellow and darker fine-grained sandstone to 0,4-0,5 m thick. These marls are rich in marine molluscs gastropods mainly Pleurotoma, bivalves, benthic and planktic foraminifers, inhabitants of moderate depth (Pashko 1970; 1972) and on the molluscs can by correlated with Tortonian Saint'Agata marls of North Italy (Robba 1968). The topmost part of this marine succession, more or less 90-97 m thick below, the first massive gypsum bodies consists of grey-blue clays and marls with gypsum crystals characterized by oligotypical foraminifer assemblage and extinctions of molluscs. This strong environmental change suggesting a rapid change of open normal marine to evaporitic conditions coincides with onset of Messinian Salinity Crisis (onset-MSC) and it represented the Tortonian/Messinian boundary.

Both figure 1b and photo 1 show the Gips-Sharrë Gypsum consisting of a cyclic succession of crystalline selenite gypsum beds and gray-blue marls intercalated with thin (5-12 cm thick) sandstone layers. Both the outcrop of the Mengaj section and the subsurface successions consist of 9-12 gypsum beds usually from 0,5 m to 20,0 m thick separated by 3-4 m to 10-14 m thick marls. Gypsum beds, 3-5 thick, could be met in the lower part of the unit. The first giant basal gypsum consists of 60 m thick, massive selenite bed, which laterally passes to 2-3 several more thinner beds separated by more 10-12 m marls interval. In the lower part which is 37 m thick, this massive bed composed of grey–brown very regular large selenite crystals up to 10-12 centimeters thick (Photo. 2a) and upwards is followed by the massive selenite gypsum, white in color with predominant gray-pink spots and microcrystalline platy gypsum with needle or grass-like crystals (Phot. 2b). The detrital fine-grained dolomites of 0,25-0,30 m thick and grey-blue marl up to 12 m thick could be met within this massive selenite gypsum. The upper part of succession comprises interbedded 2-4 m thick white massive selenite beds and usually 10-14 m thick marls. One 3 m thick selenite bed laterally

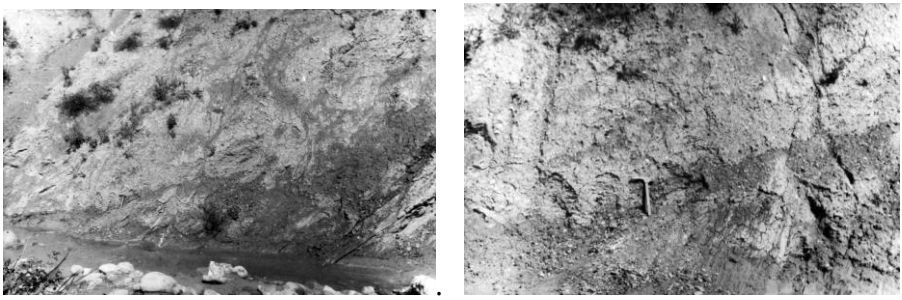
passes in gypsarenite with debris of oyster shells. In the subsurface, the uppermost gypsum bed is represented by an approximately 10 m thick rhythmic alternation of thin gypsum and clay layers (laminated gypsum) ranges from several centimeters to 1,0 m thick. The Gips-Sharrë Gypsum made of primary selenite without chaotic character can by correlated with the Lower Gypsum unit of Mediterranean especially Sicilian Messinian and was accumulated in the shallow-water conditions in a subsiding basin. The marls are of grey to light blue color, highly clay or sandy marls. The Gips-Sharrë Gypsum is up to 300 m thick.

a **b**

Photo 2. Large selenite crystals of basal giant selenite (a) and grass-like crystals (b)

The Figure 1c shows that the salt does not outcrop. In addition, it could be indicated in subsurface by the boreholes usually up to 50-60 m thick of thicker gypsum group (Cocoli *et al*., 1989; 1992) of the Gips-Sharrë gypsum group. In several boreholes they could be met at about 2-6 m over of the thin (0,7-2 m) gypsum bed. Salt consists of a massive mainly Halite salt bed of 16 m to 30 m thick and some kilometers extension (Mengaj salt mine) with 2-4 clay lentes of about 1 m thick. At the base, the 2-3 m thick of the salt bed consists of intercalation of fine salt layers of 0,2-0,3 m thick, partly of gypsum clasts and marls from 2-3 to 5 centimeters in diameter and clay layers of 0,2-0,8 to 1,5 m thick. Rarely the massive salt bed is overlaid by a thin gypsum layer of 0,4-0,5 m thick. Salt consists of halite (NaCl =80-90 %) with minor salts K (K_2O=0,024-0,066) and Mg (MgO=print). The salt deposited during the major phase evaporative indices the acme of the MSC and it accumulation start in the main deeper areas of the basin and ends with desiccation (Roveri *et al*., 2008a). In the Kavaja succession the salt is overlaid by a conglomeratic layer (interval 53 Pashko *et al*., 1969a) of 1.0–1.5 m thick predominantly composed of rounded small from 0,5-2 to 4-6 centimeters pebbles mainly of carbonates with minor ophiolites and clast of marls of the Lower Gypsum (Phot. 3), and also is marked by a slight angular unconformity. This important erosional surface correspond to the Messinian

erosional surface (MES) which separate the salt unit (also Lower Evaporites) of Mushnike Gypsum unit (also Upper Evaporites) represents a subaerial exposure and have developed during an important, intra-Messinian tectonic phase (Roveri *et al*., 2008c).



a **b**

Photo. 3. Conglomeratic layers of Messinian erosional Surface in Kavaje section (a) and it detail (b) (Pashko *et al*., 1969a).

Upper Evaporites

The Figure 1d depicts the Mushnike Gypsum. The lower part of the unit consists mainly of the rhythmic alternation of the grey clays and marls with scarce thin fine-grained sandstone layers, usually of 10-25 to 40 centimeter thick, but two of sandstone bodies (int. 55 and 57 of Kavaja section) reaches 12.8 m and 14.0 m thick respectively, represented by massive coarse-grained concretionary that shows cross-bedding and ripples and include several small carbonate pebbles. The upper part of the unit is characterized by a rhythmic alternation of thicker marls and sandstones comprise two massive selenitic beds or gypsum arenite, rich in fine grained clastic materials (clays, mudstone) which frequently laterally changed both in its composition, gypsum/mudstone and thickness that varied from 2-4 m to up 7 m thick. The Mushnike Gypsum Unit is up to 234 m thick.

The Fig. 1e depicts the Post-evaporite, Over Gypsum Marls. It represents the uppermost part of the Messinian sequence and consists of 82 m thick sequence of the regular alternation of grey marls and clays with thin sandstone layers, often very frequent grading to a rhythmic cyclic succession of 5-10 m thick marls and 3-5-7 cm thick sandstone layers. In addition, it contains the small nodules of white carbonatoceous sands. The appearance of oligotypical foraminifer's assemblage is represented by well preserved and abundant hypohaline benthic and marine planktonic foraminifera that indices brackich to slighty hyperhaline conditions, probably the Lago Mare environments. The Pliocene deposits (Fig. 1-f), through a layer of massive, coarse-grained sandstones and gravel-conglomerates, 10-12 m thick, overlay

the Messinian deposits and followed by grayish-blue deep marine marls with molluscs and foraminifers (Acme *Sphaeroidinellopsis* Zanclean stage).

Marginal shallow sub-basins

The Messinian evaporitic succession also crop out in the peripheral or marginal sub-basins located in north, Durres and south, Vlore margins of PAD that are developed in different depositional conditions. Its Messinian succession is characterized by incomplete evaporitic succession, represented only by its lower part and comprises the pre-evaporite Under Gypsum Marls and Gyps-Sharrë Gypsum cuttings on top by erosional surface and overlies by transgressive normal marine Pliocene (Zanclean, Acme *Sphaeroidinellopsis*) deposits with a slight angular unconformity.

In the Durrës sub-basin (Aremadh and Manzë sections), the pre-evaporite marls consist of 88-90 m thick intercalations of marls and thin sandstone layers overlain by 240-290 m thick marls intercalated with sandstones and two selenite beds and (basal of ~ 15 m and upper of 4-5 m thick) the Gips-Sharrë gypsum unit. The Messinian succession up to 210 m thick in the Vlora area comprises pre-evaporitic marls 86 m thick and Gips-Sharrë gypsum unit up to 120 m thick which consists predominantly of massive selenite beds and one dolomite layer (0,3 m) intercalated with more thin bluish marl layers.

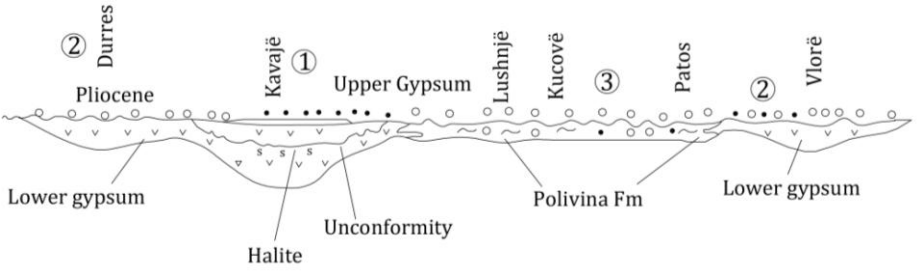


Fig. 2. Schematic geologic cross-section across the PAD that shows the physical-stratigraphic correlation between Messinian basins: 1. evaporitic subsiding Kavaje basin. 2. Marginal evaporitic Durres and Vlore shallow-water basins. 3. Lateral siliciclastic fluvial-deltaic facies basin (Polovina Fm.).

The gypsum unit comprises three thick massive selenite beds: the first basal of 16-17m thick, the second of up to 27 m and upper of up to 50 m thick (Vlora section). In the Vlora town (Kuzbaba), most of the thick massive selenites beds mainly consist of large selenite crystals.

Moving southward along the edge of PAD, to Rrogozhina, the evaporite Messinian succession of the Kavaja basin undergoes an abrupt and sharp facial change in lithology grading to a thick siliciclastic unit, characterized by

the occurrence of lateral facies of the coarse and medium grained sandstones and conglomerates (Polovina Fm up to 180 m thick), with some meters long silicified woods (in Patos) recording a continental environment of typical fluvial-deltaic activity (Fig. 2 Polovina Fm).

Biostratigraphy

The physical and biostratigraphical approaches allow establishing a chronostratigraphy of sedimentary successions of the Messinian Evaporites of PAB. The Tortonian normal marine foraminiferal and mollusc mainly gastropoda assemblages, similar to those of Tortonian type (Robba 1968), in topmost Mengaj formation at 97 m (Kavaja section) below the first gypsum bed are followed by oligotypical faunal assemblages characterized of scarcity and decrease in the faunal diversity and abundance. This environmental and faunal change is the source for the stressed environments, related to increase salinity and indices the onset of the Messinian Salinity Crisis. Basing on (Garori 1969; Pashko *et al*., 1969ab), the foraminiferal assemblage are equal in all clays-marls underlying lower and upper gypsum sequences and is dominated by stress tolerant, dwarf planktonic and light diverse benthic, mainly brackish species (*Ammonia beccarii*, *A. tepida* and many *Bulimina*, *Bolivina*). Ostracoda is represented by the rare *Cyprideis*, mainly in lower gypsum marls of marginal basins. Mollusc assemblage characterized by scarcity (in Under Gypsum marls) or missing (in evaporite units) of the marine molluscs, and include several Tortonian species represented of many number specimens usually with small shells. In Salt are found The fish remains of *Myctophum* have been found in the salt sediments. The evaporite foraminiferal assemblage generally brackish to hyperhaline gradually evolved, and after Upper Gypsum, following towards hypohaline and is represented by well preserved and abundant hypohaline benthic and marine planktonic foraminifera. Prillo *et al*., (1992) said that Messinian evaporites belong to the "non-distinctive zone". Pliocene deposits yields marine molluscs and foraminifers (Acme *Sphaeroidinellopsis*) and represents the return to fully marine conditions after Messinian Salinity Crisis.

CONCLUSIONS

The base of the Messinian stage is defined in the topmost part of marine Tortonian Mengaj Fm., about 97 m below the first gypsum beds (Pre-evaporite deposits) where a sharp environmental change coincides with a rapid impoverishment of molluscs and the dominance of dwarf planktonic foraminifera proves the onset of Messinian Salinity Crisis. The Messinian Evaporites comprise the Gips-Sharrë gypsum unit that consists of a cyclic succession of up to 9-12 crystalline selenite beds and gray-blue marls with

thin sandstone layers, followed by a 16-30 m thick massive salt unit separated by a regional erosion surface (MES) of the Mushnike gypsum unit which represented mainly the rhythmic alternation of the grey marls with thin fine-grained sandstones and two (4 and 7 m) selenite gypsum beds, laterally passes in gypsarenite. Upwards, post-evaporite over gypsum marls unit consists of alternation of marls and thin sandstone with well preserved, abundant hypohaline benthic and marine planktic foraminifera. The complete succession of the evaporites exposed in the Kavaje region are accumulated in a subsiding basin, whereas incomplete succession of the marginal Durrës and Vlorë sub-basins is accumulated in shallow sub-basins developed in different depositional setting above the tectonic areas. The non-marine Messinian siliciclastic deposits are accumulated within fluvial-deltaic conditions.

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ANALYSIS OF BUNA RIVER FLOW UNDER THE INFLUENCE OF DRINI RIVER USING SOBEK SOFTWARE

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ABSTRACT

The project "Development of hydrological and hydraulic study of regulation of Shkodra Lake and Buna River water regime" was carried out between the the Academy of Sciences of Albania, and the Academy of Sciences and Arts of Montenegro under the IPA Albania-Montenegro project. The SOBEK software was used to analyse the flow of Buna River under the influence of Drini River and some of the results are here reported. This software was provided in the framework of the IPA Albania-Montenegro project, which was founded by the European Union. Shkodra Lake, Buna and Drini River water system is one of the most hydrologically and hydraulically complex water systems in the country. Shkodra Lake is the largest lake in the Balkan Peninsula, intersecting Albania and Montenegro. Drini River is the longest river in the country, with a total length of 335 km (208 mi) of which 285 km (177 mi) flows in Albania. In addition, it is the largest river in the country and in the whole Adriatic Coast of the Balkan Peninsula regarding both watershed surface and water flow. Buna River with a total length of around 44 km, discharges through its river bed the waters of Shkodra Lake and Drini River into the Adriatic Sea. Buna River flows in a low land area allowing flood water to flow over agricultural land and urban areas in both countries.
Keywords: hydraulic model, water level fluctuation, Buna River, Drini River, SOBEK software

1. INTRODUCTION

Shkodra Lake, Buna and Drini River water system accumulates all the waters in a general surface of 19580 km^2. Drini River and its branches has a total drainage surface area of 14400 km^2. Shkodra Lake and its inflows has a surface area of 5180 km^2 (IHM, 1984). This water system comprises Shkodra Lake with Moraça stream, Buna River, and Drini River and its branches, Kiri

and Gjadri River. The general surface of the basin of this water system is expanded in Albanian, Montenegro, Kosovo, and Macedonia.

Shkodra Lake is relatively shallow, with a depth varying from 7 to 10 m. It is a two-border lake shared by Albania and Montenegro (40^{o} 10' N 19^{o} 15' E) and the largest lake of the Balkan Peninsula, with a surface which varies from 370 km^2 to 600 km^2 depending on climate characteristics. This lake is a special one, as its water level fluctuates from 4.39 m to 9.40 m (IHM, 1984).

Buna River, in the distance from the upstream flow near Shkodra Lake to the Adriatic Sea where it discharges, is 44 km. At a distance of 1.5 km downstream from its outflow, Shkodra Lake, Buna River joins the Drini River flow.

Drini River is the longest river of east Adriatic and Ionian Seacoast. Its bed has changed a lot, and in the winter of 1846, Drini River formed the current bed. The figure 1 depicts the geographic position of the area here investigated.

Fig.1. Geographic position of Shkodra Lake, Buna and Drini River water system (Source: Google Physical)

Shkodra Lake, Buna and Drini River water system is one of the most complicated hydrological complexes in Albania due to a very big water basin, the heavy rainfall events from October to April, and the concentration of water in Buna River after the confluence of Buna River with Drini River (Stratobërdha *et al*, 2002).

The aforementioned factors allow flood water to flow over agricultural land and urban areas in both countries.

2. MATERIALS AND METHODS

The SOBEK software involving a mathematical model applied also in (Abazi, 2005) was used to investigate the hydraulic regime of Shkodra Lake, Drini and Buna River water system. This software was provided in the framework of the IPA Albania-Montenegro project: "Development of hydrological and hydraulic study of regulation of Shkodra Lake and Buna River water regime" between the Academy of Sciences of Albania and the Academy of Sciences and Arts of Montenegro.

2. 1 The SOBEK software

SOBEK software is developed from the Deltares Institute in Delft, Netherland in partnership with the National Dutch Institute of Inland Water Management and Wastewater Treatment (RIZA), and the major Dutch consulting companies. This software is designed to perform one-dimensional hydraulic calculations for a full network of natural or constructed channels, and also 2Dimensional hydraulic calculations on two-dimensional (2D) horizontal grids.

SOBEK is an integrated software package for river, urban or rural management. Seven modules work together to give a comprehensive overview of waterway systems. SOBEK is based on high performance computer technology that means it can handle water networks of any size - big or small (Deltares, 2013).

The "Settings" task block in the figure 2 was used to select the SOBEK modules that need to be included in the model. In addition, computational parameters such as calculation time steps, simulation period and initial water levels can be set in the "Settings" task block.

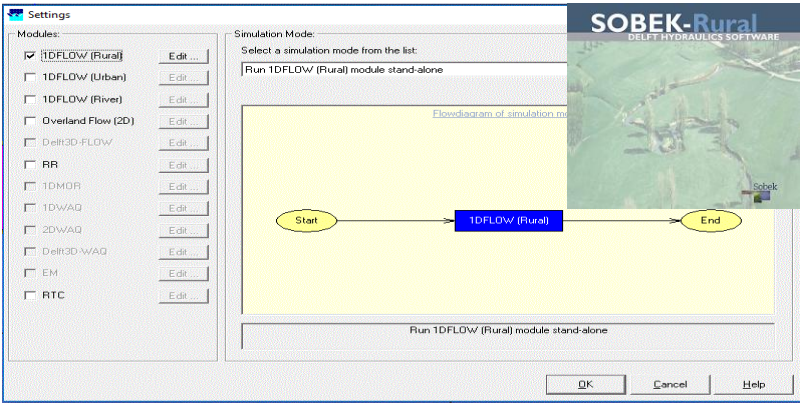


Fig. 2. The "Settings" window of SOBEK software

The 1DFLOW module in SOBEK was applied to build the mathematical model for the water system of Shkodra Lake, Drini and Buna River. This module consists of a network of reaches connected to each other at connection nodes. In each reach, a number of calculation points are defined. These calculation points represent the spatial numerical grid to be used in the simulation. The computation of the water levels and discharges in the SOBEK-flow-network is performed with the Delft-numerical scheme. This scheme solves the Saint Venant equations (continuity and momentum equation) by means of a staggered grid.

2.2. Model equations

The water flow is computed by solving the complete Saint Venant equations. For one dimensional flow (Channel Flow module) the water flow is defined by the state variables discharge **Q**, and water level **h** as function of the independent variables **t** for time and **x** for space.

Basic assumptions of the Saint Venant equations for 1D flow according to (Cunge *et al*, 1980) are: i) discharge sufficiently well-defined as the integral of the velocities through a cross-section perpendicular to the x-axis, ii) a constant water level along the cross-section. This implies that at any time the water level, at all points along a given cross-section should rise or fall at the same rate, iii) hydrostatic pressure distribution is in the vertical, iv) the resistance relationship for steady flow also applicable for unsteady flow and, v) the bed slope moderately steep, so that the cosine of the slope can be replaced by unity.

The Saint Venant equations expressed in their non-conservative form per unit width of channel are as follow:

Continuity equation

$$\frac{\partial \zeta}{\partial t} + \frac{\partial (uh)}{\partial x} = 0 \qquad (2.1)$$

Momentum equation

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + g\frac{\partial \zeta}{\partial x} + c_f \frac{u|u|}{h} = 0 \qquad (2.2)$$

where:

ζ - water level (with respect to the reference level) defined as $\zeta = h + z_b$ [m]

h- local water depth [m]

z_b - the local bottom level [m]

u - flow velocity [m/s]

c_f - the dimensionless friction coefficient

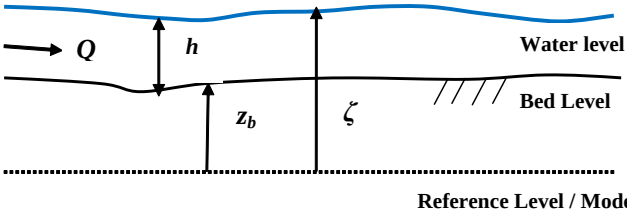


Fig. 3. Representation of the terms of the Saint Venant equations

2.3. Numerical aspects of 1D modelling in SOBEK software

The water flow is computed by solving the complete Saint Venant equations. For the Channel Flow module in SOBEK software, the Saint Venant equations are solved numerically using a robust numerical scheme proposed by Stelling (Stelling and Duinmeijer, 2003) called Delft Scheme. This scheme solves the continuity and momentum equation by means of a staggered grid and implicit integration scheme. In this staggered grid the water levels are defined at the connection nodes and calculation points (1D nodes), while the discharges are defined at the intermediate reaches or reach segments. The momentum equation and continuity equation will be solved numerically on this grid, which results in the hydraulic states at the calculation points and the reach segments.

The characteristics of Delft Scheme are as follow: i) mass conserved not only globally but also locally and, ii) the total water depth guaranteed to be

always positive which excludes the necessity of "flooding and drying" procedures.

A common staggered grid is applied as presented in figure 4, and the explanation of the Delft Scheme proposed by Stelling (Stelling and Duinmeijer, 2003) is given below.

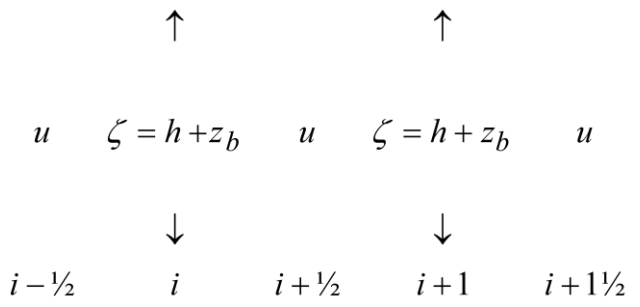


Fig. 4. Stagger spatial grid used in 1D modeling in SOBEK software

2.4. Setting up the Hydraulic Model in SOBEK

The hydraulic model using SOBEK software is set-up based on the digital terrain model in WGS-84 coordinate system (Pandazi, 2011) developed from the topographic survey made in the study area during the period 2005-2006, from the Albanian Academy of Sciences and the Montenegrin Academy of Sciences and Arts (ASA and MASA, 2006).

The digital terrain model was processed in ArcViewGIS software providing that all geometric parameters (river thalweg, river banks, cross-sections, land use, river confluences data, etc.) to be returned to an acceptable format for the hydraulic software SOBEK. The hydraulic model built in SOBEK software for the Water System of Lake Shkodra, Drini and Buna River is in the figure 5 depicted.

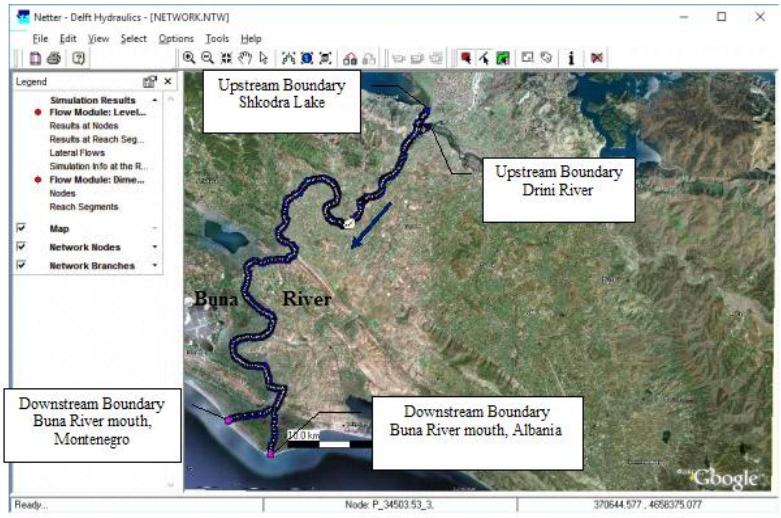


Fig. 5. The hydraulic model scheme built in SOBEK software.

One of the major steps in developing a hydraulic model in SOBEK is entering the cross sections data. Consequently, a large number of cross sections being available to accurately describe the geometry of the river system would be very important.

The cross section data are at interval of around every 100 m along the river axes of the Buna River and the downstream part of Drini River. For the Water System of Shkodra Lake, Drini and Buna River were used 395 cross sections, where 15 cross sections in the Shkodra Lake, 14 cross sections describing the mouth of Buna River in Montenegro, and 12 cross sections describing the mouth of Buna River in Albania. In the case of the Shkodra Lake, Drini and Buna River water system, in addition to Buna River cross sections, are taken into consideration 9 cross sections in the downstream part of Drini River (1km before joining Buna River).

Cross sections measured from the teams of the two countries were investigated for data errors. Due to the huge amount of information of cross sections in Excel sheets and AutoCAD files, some discrepancies were found between the Excel data and graphic representation of cross sections in AutoCAD. They were corrected for a better representation of river bed.

Another important element which describes the river cross sections is the bed flow resistance coefficient. For the hydraulic model built in SOBEK it was used the Manning's n resistance coefficient. For the river's cross sections in SOBEK (which are Y-Z profiles) are used different Manning's *n* values for the left overbank, main channel, and the right overbank. Figure 6 depicts the Manning values for a selected river cross section of the hydraulic model of the

Water System of Shkodra Lake, Drini and Buna River built in SOBEK software.

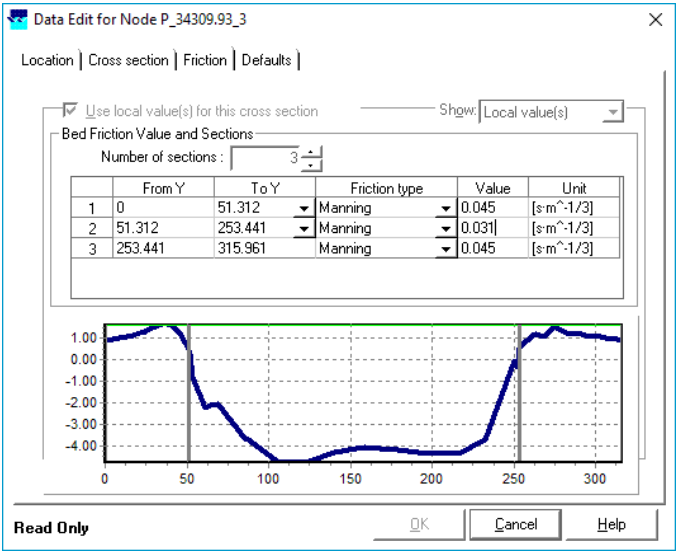


Fig. 6. Representation of the bed resistance coefficient for the model built in SOBEK

For the estimation of Manning's *n* values, the tables and figures compiled by Chow (1959) were used. These tables give a range of values for Manning's *n* according to a description of the channel, considering its nature and its characteristics. In order to have a reliable model, the flow resistance coefficient *n* values estimates are then refined during the calibration process.

3. RESULTS AND DISCUSSIONS

Once the model for the water system of Shkodra Lake, Buna and Drini River was calibrated, different scenarious were taken into consideration based on hydrological data generated from the hydrological investigation which was part of the project (Hoxhaj *et al*, 2015).

Hydrological data (Hoxhaj *et al*, 2015) reported that the mean annual discharge of Drini River in Bahçallëk is 351 m^3/sec, whereas the mean annual discharge of Buna River before the conflunce with Drini River is 320 m^3/sec. The mean annual dicharge for Buna River after the confluence with Drini River until the Adriatic Sea results in 671 m^3/sec. Figure 7 depicts the water level variations along the Buna River from Shkodra Lake outflow to the Adriatic Sea for the mean annual discharge.

The hydraulic regime of the water system of Shkodra Lake, Buna and Drini River was investigated during the low flow (5-18 November 2014) and high flow (25 January -24 February 2015) period. The inflow hydrographs of hourly data in Buna River at Buna Bridge, and at the Bahçallëk Bridge in Drini River gauging station were used. These online stations were installed from the World Bank project (World Bank, 2014).

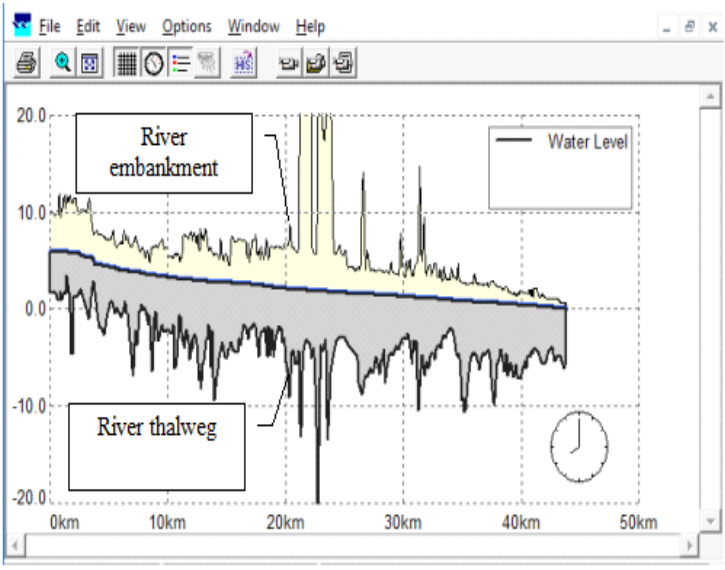


Fig. 7. Water levels along Buna River for the mean annual discharge

3.1. SOBEK model results for the low flow period

The low water level was recorded between 5 and 18 November 2014. Water levels at the downstream part of Drini River and along Buna River predicted from the hydraulic model built in SOBEK software were also investigated.

Once the hydraulic model built for Buna River in SOBEK software was run, the water level variations for the period of low flow were generated. Figure 8 depicts maximum water levels along Buna River for all the cross sections along the river, from Shkodra Lake outflow to the Adriatic Sea. Maximum discharge for the selected period was 450 m^3/sec.

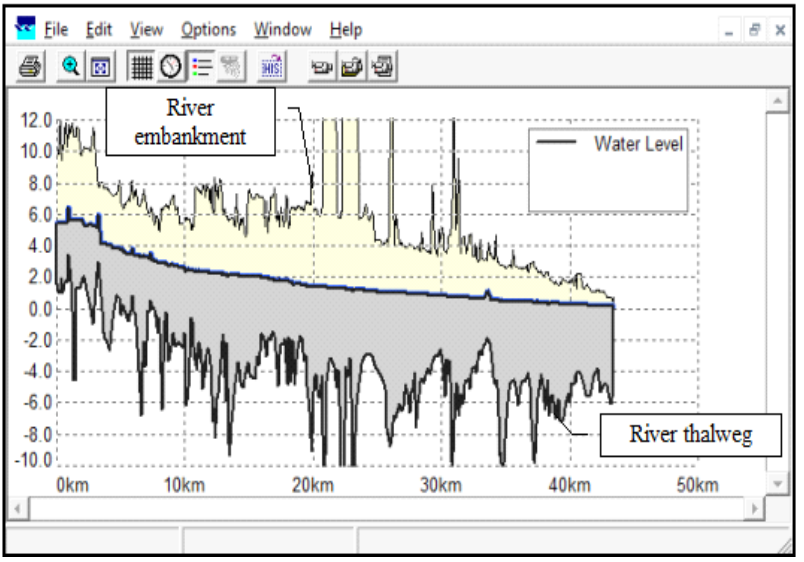


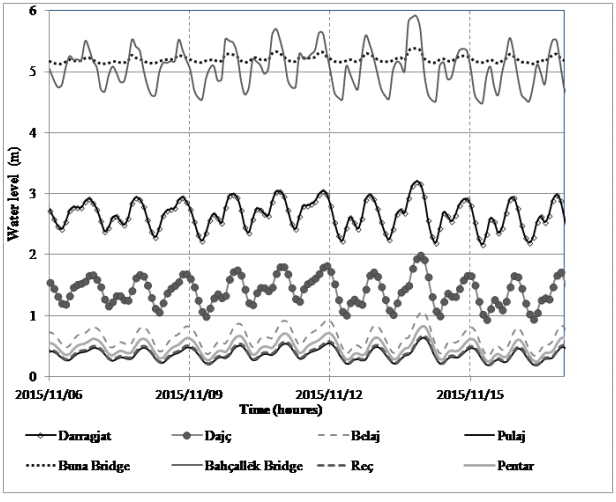
Fig. 8. Maximum water levels along Buna River for the low flow period

Drini River is the longest river in Albania and the largest in the whole Adriatic Coast of the Balkan Peninsula regarding both watershed surface and water flow. Drini River is a regulated river where several dams are constructed along its path, and its water regime is influenced from the operation of the dams.

The cross section in Buna Bridge, before the confluence of Buna River with Drini River and some cross sections after the confluence were selected to investigate the water levels along Buna River. The selected cross sections after the confluence of Buna River with Drini River are near the villages Darragjat, Dajç, Belaj, Pentar, Reç, Pulaj (Figure 9).

Fig. 9. Location of the cross sections used to analyse Buna River flow

Results from the simulations of water level variations in time for the selected cross sections along Buna River from its outflow from Shkodra Lake until Adriatic Sea, and the downstream part of Drini River for the low flow period in graph 1 plotted.



Graph. 1. Water level variations in time for the selected cross sections along Buna River, and the downstream part of Drini River for the low flow period.

The maximum daily fluctuation of water levels in Bahçallëk Bridge (Drini River) is 1.5 m for the selected period of low flow. The maximum daily fluctuation of water levels for the selected period of low flow for the cross sections in Buna River after the confluence with Drini River were as follow: Darragjat=1.0 m, Dajç=1.0 m, Belaj=0.6 m, Pentar=0.5 m, Reç=0.4 m and Pulaj=0.4 m.

Drini River has a great influence on the Buna River flow for the period of low flow. Daily water level fluctuations of Drin River have an impact on the water level variations of Buna River downstream from the confluence to Pulaj village (close to Buna River mouth). The source is the operation of the Vau Dejës hydropower.

3.2. SOBEK model results for the high flow period

The hydraulic regime of the water system of Shkodra Lake, Buna and Drini River for the high flow period (25 January -24 February 2015) was also investigated. The inflow hydrographs of hourly data in Buna River at Buna Bridge gauging station and at the Bahçallëk Bridge in Drini River were considered.

Water levels at the downstream part of Drini River and along Buna River predicted from the hydraulic model built in SOBEK software were investigated. Once the hydraulic model built for Buna River in SOBEK software was run, the water level variations for the period of high flow were generated. Figure 10 depicts maximum water levels in all the cross sections along Buna River from Shkodra Lake outflow to the Adriatic Sea for the high flow period. Maximum discharge for the selected period was 1100 m^3/sec.

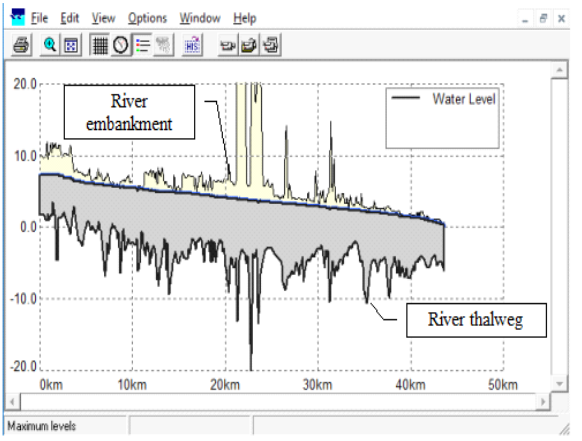
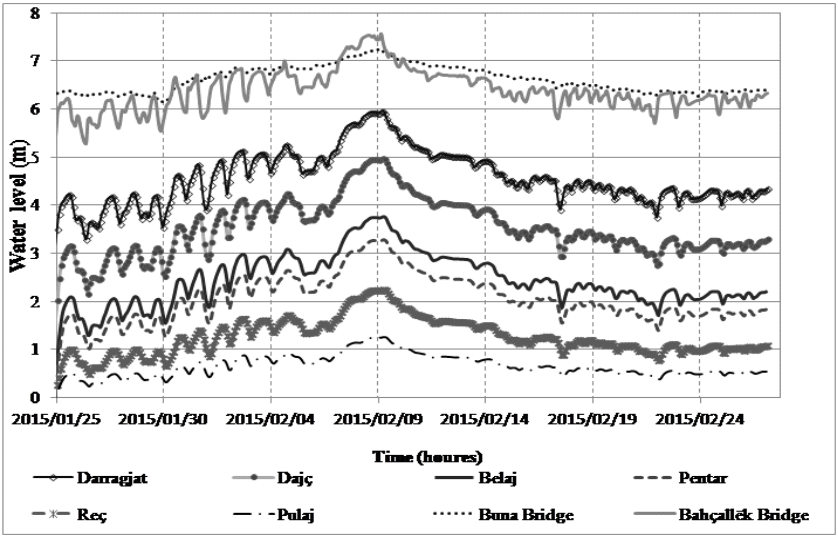


Fig. 10. Maximum water levels along Buna River for high flow period

Water level variations in time for the selected cross sections along Buna River from its outflow from Shkodra Lake until Adriatic Sea, and the downstream part of Drini River for the high flow period are in the graph 2 plotted.



Graph. 2. Water level variations in time along Buna River, and the downstream part of Drini River for the high flow period

The maximum daily fluctuation of water levels in Bahçallëk Bridge (Drini River) was 1.0 m. The maximum daily fluctuation of water levels for the selected period of high flow for the cross sections in Buna River after the confluence with Drini River were as follow: Darragjat=0.9 m, Dajç=0.9 m, Belaj=0.8 m, Pentar=0.7 m, Reç=0.5 m, and Pulaj=0.3 m.

4. CONCLUSIONS

Shkodra Lake, Buna and Drini River water system is one of the most complicated hydrological complexes in Albania due to a very big water basin, the heavy rainfall events from October to April, and concentration of water in Buna River after the confluence of Buna River with Drini River.

The hydraulic model set up in SOBEK software, was involved for the hydraulic regime of the water system of Shkodra Lake, Buna and Drini River. This software, developed from Deltares Institute in Delft, Netherland, was provided in the framework of the IPA Albania-Montenegro project. The hydraulic model using SOBEK software was set-up based on the digital terrain model in WGS-84 coordinate system, developed from the topographic

survey made by the teams from both countries in their respective national coordinate systems in 2005-2006. The hydraulic model of the study area involved 395 cross sections, which were located at intervals of around every 100 m along the axes of Buna River and at the downstream part of Drini River.

Buna River flow was analysed for the mean annual discharge, and also for a period of low flow and high flow based on hourly data in Buna River at Buna Bridge gauging station and at the Bahçallëk Bridge in Drini River. Water level variations along Buna River from Shkodra Lake outflow to the Adriatic Sea for the mean annual discharge, for the period of low flow, and the period of high flow are here reported.

Stage hydrographs at the selected cross sections located in the downstream part of Drini River and along Buna River predicted from the hydraulic model built in SOBEK software were analysed for the period of low flow and high flow.

The simulation in SOBEK reported that Drini River flow has a big impact on the water regime of Buna River. Daily fluctuations of Drin River flow have an impact on the water levels variations of Buna River downstream from the confluence to Pulaj village (close to Buna River mouth). The source is the operation of the Vau Dejës hydropower plant.

In the upper part of Buna River, from the confluence with Drini River until Belaj, the impact of Drini River fluctuations on the Buna River flow is higher than in the lower part from Belaj village to Buna River mouth.

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A COMPARATIVE STUDY OF ALTERNATIVE IMMOBILIZATION TECHNIQUES AND THEIR IMPACT IN FERMENTATION CHARACTERISTICS OF YEAST CELLS

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ABSTRACT

The present investigation aims at finding the most suitable immobilization technique in terms of fermentation process, kinetic parameters and yeast cell conditions compared to the free cell fermentation. Applying the right immobilization technique is very important for the cells as their activity, morphology and physiology ought to be preserved, and a high cell concentration retained in the immobilized bead. Consequently, three different immobilized yeast fermentation processes are here compared. A brewing strain of *Saccharomyces cerevisiae* was involved and entrapment and capsulation method in alginate and immobilization in gelatine structure were applied. Batch and continuous fermentation were both involved. The vitality of the yeast cells, specific growth and the sugar uptake rate depend on the medium conditions and permeability of support, also known as the "skin effect". Results of gel immobilization showed that the immobilization support is unstable and dissolves into the fermentation medium. Consequently, the immobilization technique did not have any impact on the fermentation process. Neither the entrapment method, nor the capsulation immobilization method showed differences between fermentation processes. However, there were differences compared to free yeast cell fermentation rate. As tolerance of substrate and product inhibition were both increased, the yeast cells were easily separated from the liquid phase.
Keywords: fermentation rate, immobilization, entrapment, capsulation, gelatin, inhibition, batch fermentation, continuous fermentation

1. INTRODUCTION

Immobilization technique is a means to address maximum yeast concentration. Once the maximum yeast concentration is achieved, a higher

productivity and fermentation rate could be obtained and expenses reduced (Banik, 2005). Cells are surrounded by a biocompatible matrix with a specific permeability, which allows small sized molecules, such as nutrients and oxygen to enter the beads and toxic metabolites to exit the matrix, giving the cells the ability to protect themselves and create an optimal growth environment. Cell immobilization in alcoholic fermentation is a rapidly expanding research area because of its technical and economic advantages compared to the conventional free cell system (Margaritis and Merchant 1984; Stewart and Russell 1986). This is mainly due to the numerous advantages that cell immobilization offers including enhanced fermentation productivity, feasibility of continuous processing, cell stability and lower costs of recovery, recycling and downstream processing (Kourkoutas *et. al*., 2003). Kinetics of fermentation with immobilized yeast is also affected by permeability of the capsule. Permeability in the matrix membrane is changed by making this layer thinner or increasing the concentration of substrate. Applying the right immobilization technique is very important for the cells as their activity, morphology and physiology ought to be preserved, and a high cell concentration retained in the immobilized bead.

Specific growth rate is usually affected by the presence of inhibition components in the bioreactor. Any deviation from normal correlation of specific growth rate and substrate concentration, show the substrate impact on cell growth, therefore over the fermentation process. Here, applying the *Andrews* equation (eq:1) would be appropriate. Kinetic constants were calculated based on the *Monod model*, known as the mathematical model for the growth of microorganisms (eq:2) (Xhangolli and Malollari 2009)*:*

$$\mu = \frac{\mu_{max} s}{K_s + s + K_i s^2} \mu = \frac{\mu_{max} s}{K_s + s + K_i s^2} \qquad \text{(eq:1)}$$

$$\mu = \mu_{max} \frac{s}{K_s + s} \mu = \mu_{max} \frac{s}{K_s + s} \qquad \text{(eq:2)}$$

K_i -the inhibition constant
s –substrate concentration (g/l)
Ks – half velocity constant, the value of s when $\mu/\mu_{max} = 0.5$
μ -the specific growth rate (h^{-1})
μ_{max} - maximum growth rate

2. MATERIAL AND METHODS

1. Cell Immobilization

The three different immobilization techniques used require yeast cells to be incorporated in a semi- permeable matrix:

1.1. Capsulation Immobilization

Here, a 1,3% calcium chloride $CaCl_2$ and 1,3% of carboxymethylcellulose solution and a 0.6% solution of sodium alginate (figure1A) was prepared (Sultana *et al*., 2000; Canaple 2002; Rrathone *et al*., 2013).

1.2. Entrapment Immobilization

Here, yeast cells were mixed with the Na-alginate 6% and poured drop by drop in the calcium chloride solution 0.1 M and left for 30 minutes in order to increase their stability (figure 1B), (Duarte *et al*., 2013 and http://www.fao.org/docrep/w7241e/w7241e0a.htm).

1.3. Gelatine Immobilization

A 10% solution of gelatine was prepared and mixed with yeast cell suspension, providing a solid structure for the yeast. A 20% formaldehyde solution was added to increase the stability of the gel prepared. Once the stability was increased, the gel was stored in fridge in 4^{o}C for 30 min (figure 1C), (Xhangolli, 2016).

A B C

Fig.1: immobilized yeast: a-capsulation immobilization, b- entrapment immobilization, c-gelatine immobilization

2. *Fermentation*

Periodic fermentation was carried out, in 250 ml volume in 12^{o}Bx substrate concentration (Figure 2), all inoculated with 5 gr immobilized yeast as described in section 1. Fermentation was carried out twice by the same beads to survey the stability of the support matrix. Once the best fermentation performance was evaluated, continuous fermentation was carried out (Figure 3) involving entrapment and capsulated immobilized yeast, in a 1000 ml volume, with the same regime flow 2.77 ml/min. Fermentations in 250 ml volume in 20 ^{o}Bx medium and 12 ^{o}Bx + 10% alcohol, inoculated with cell suspension and immobilized yeast were carried out to investigate the substrate

and product inhibition and the impact of immobilization techniques on decrease of inhibition factors.

Fig. 2: Batch fermentation.

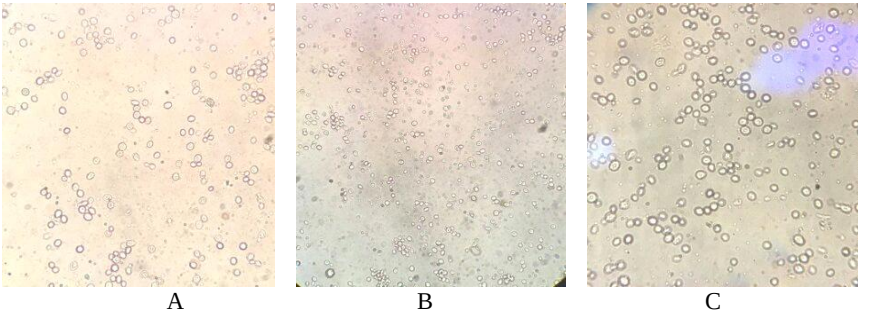
Fig. 3: Continuous fermentation.

During fermentation, immobilized beads lost support stability and released yeast cells in the medium. Spectrophotometer was used for biomass concentration by measuring the absorbance of beer wort, in λ=550 nm, during the fermentation process.

3. RESULTS AND DUSSCUSIONS

1. Morphological characteristics of yeast cells in immobilized beads

Inappropriateness of the gelatine immobilization technique is clearly depicted in the Figure 4B. No sign of budding phase was shown and cell growth stopped. In addition, contamination rate was very high. Compared to entrapment and capsulated immobilized yeast, cell growth could be noted (figure 4A/4C). Cells were very good developed and multilateral or unilateral budding and pseudomycelium formation was shown. Cell counting performed by Thomas camera showed that cell vitality increases after fermentation in immobilized beads, compared to free cell suspension (table 1).



A B C

Fig.4: Microscopic image of immobilized yeast cells, in beads: A- capsulated immobilized yeast, B-gelatine immobilized yeast, C- entrapment immobilized yeast.

Table 1: Vitality of yeast cells before and after fermentation for immobilized yeast cells and free cell suspension

	Before fermentation	**After fermentation**
Entrapment	82.63%	89.17%
Gel	-	-
Capsulation	88.66%	92.08%
Free cell	76.63%	69.71%

2. Batch fermentation

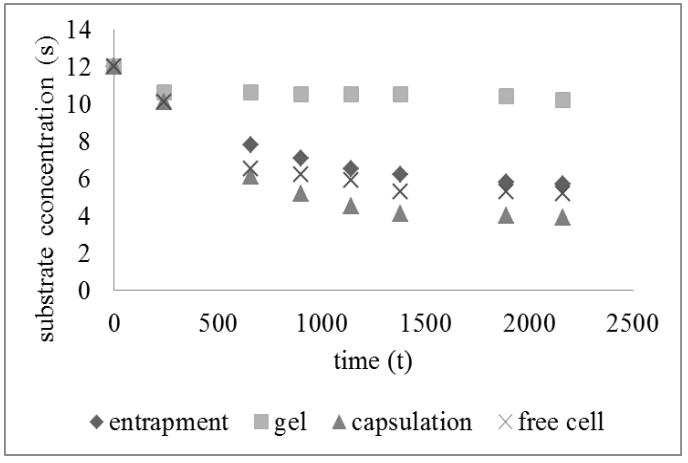
Periodic fermentation showed that the immobilization technique with gelatine was inappropriate as the support structure did not allow the cells to grow (table 2, figure 6). During the second fermentation, beads were dissolved in the medium releasing the cell-free yeast and stopping the fermentation in high substrate concentration (Figure 7).

Table2. Maximum specific growth rate (μ_{max} – hour^{-1}) and half velocity constant (K_s - gr/hour) of yeast cell in two consecutive fermentation in beer wort medium.

	μ_{max} (hour^{-1}) -I fermentation 12^{o}Bx	**μ_{max} (hour^{-1}) - II fermentation 12^{o}Bx**	**K_s (gr/hour)- I fermentation 12^{o}Bx**	**K_s (gr/hour) - II fermentation 12^{o}Bx**
Entrapment	0.0235	0.0328	47.293	38.159
Gel	0.00019	0.0000413	12.24	11.987
Capsulation	0.028	0.0335	21.287	58.872
Free cell	0.0292	0.01655	45.739	31.735

Table 2 reports that entrapment and capsulation immobilized yeast showed a higher specific growth rate during the second fermentation, compared to free cells. Figure 5 depicts capsulation immobilization having a better fermentation performance compared to entrapment immobilization fermentation, due to the thicker alginate support layer that makes the metabolites hard to exchange. These metabolites are very important for the fermentation process. During the second fermentation process, starting from 12 ^{o}Bx, entrapment and capsulated immobilized yeast had a similar fermentation performance due to unleashed support which made the metabolite exchanges easier.

If the same beads for different fermentation cycles (figure 6) are used, cell concentration in the medium could be increased because the support structure becomes less stable and releases the cells free in the medium. As the capsulated immobilized beads have the less stable and thinner support layer, biomass concentration doubles in all the fermentation processes compared to entrapment immobilized fermentation. If alcohol is added, this phenomenon could not be observed during the fermentation process (figure 6) as the product inhibition factor does not allow for an optimal growth of the cells.



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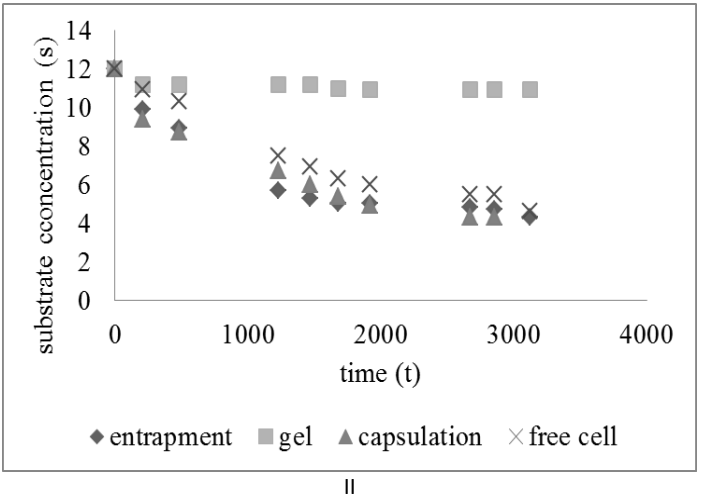

II

Fig.5: Fermentation performance with immobilized and free cells, I – first fermentation 12^{o}Bx II- second fermentation ^{o}Bx.

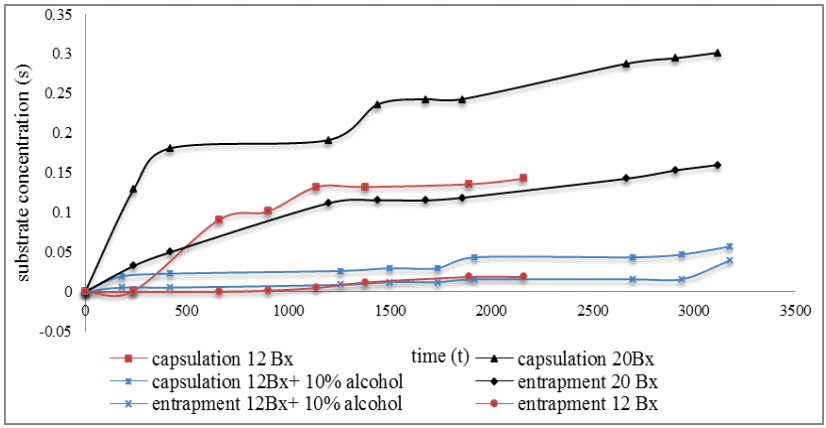

Fig. 6: Biomass concentration in beer wort medium during different fermentations.

3. Continuous fermentation

The figure 7 depicts that significant differences between entrapment and capsulated immobilized processes were not observed during the periodic fermentation. It was difficult to maintain the regime stable with the capsulated immobilized yeast. There was a constant decrease of substrate concentration because the support layer was thinner and less stable than the entrapment immobilized beads. The yeast cells were released in the medium. The process continued as a traditional fermentation.

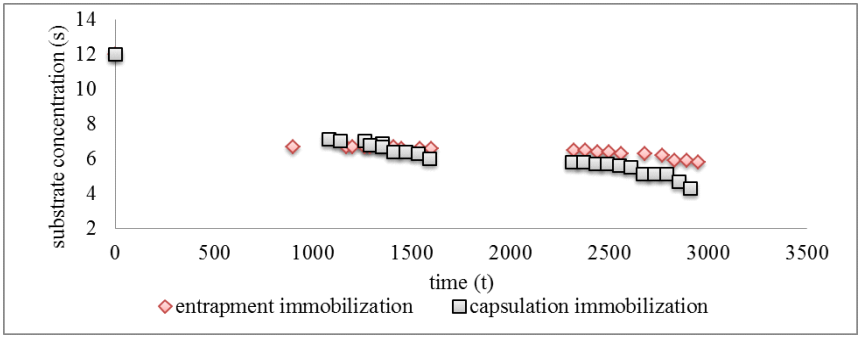

Fig.7: Continuous fermentation process with entrapment and capsulated immobilizes yeast.

4. Substrate and product inhibition

Fermentation results showed that immobilization decreases significantly the inhibition substrate and product factor (table 3) compared to free cell that stop fermentation in high substrate concentration. Despite the high sugar and product concentration, the entrapment and capsulated cells (figure 8, 9) had a

good fermentation performance. It was observed that fermentation started sooner in capsulated immobilized batch and the impact of product and substrate inhibition decreased compared to entrapment immobilization, due to the dimension of the immobilized beads and the thin surrounding matrix layer. The inhibition effect decreased as the diameter of the bead increased. At the end, the diameter of the beads increased from 1.5 to 2mm.

Table 3: Substrate and product inhibition impact in maximum specific growth rate (μ_{max} – hour^{-1}) and half velocity constant (K_s - gr/hour) of yeast cell.

	μ_{max} (hour^{-1}) fermentation 20°Bx	**μ_{max} (hour^{-1}) fermentation 12°Bx+10%alc**	**K_s (gr/hour) fermentation 20°Bx**	**K_s (gr/hour) fermentation 12°Bx+10%acl**
entrapment	0.00545	0.000818	22.999	2.959
capsulation	0.00805	0.00187	21.752	12.239
free cell	0.00574	0.000106	30.179	8.113

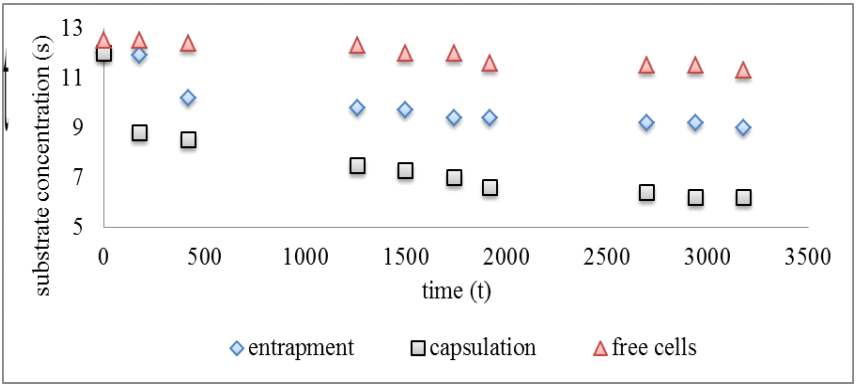

Fig. 8: Graphical representation of substrate inhibition impact in fermentation performance, 20^{O}Bx.

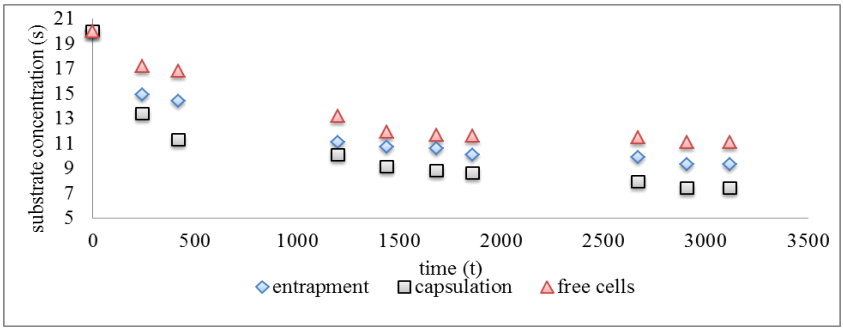

Fig. 9. Graphical representation of product inhibition impact in fermentation performance, 12^{O}Bx+ 10% alcohol.

4. CONCLUSIONS

Entrapment and capsulation immobilization techniques are applicable, effective and of economic benefit. Entrapment immobilization technique would be recommendable for use as the beads are easier to obtain, more uniform, stable and smaller in size. The maximum specific growth rate of immobilized yeast cells is approximately two times higher than the free cells after the first fermentation batch. Gelatine immobilization techniques would be unrecommendable as cell growth is not supported. During fermentation, the diameter of immobilized beads increased and structure released more cells in the medium. Entrapment and capsulated immobilization techniques protected the morphology of cells, and supported cells growth and budding. Immobilized yeast is easier to handle than the free cells. In addition, it could be reused both in batch and continuous processes. In the present investigation, they were used in a very good yeast condition, up to six batches. Substrate and product high concentration were of great impact to the fermentation performance. The impact of substrate and product inhibition decreased due to the immobilization techniques.

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SERIC MARKERS AND CELL PROFILE IN BLOOD AND SPUTUM IN *CHRONIC OBSTRUCTIVE PULMONARY DISEASE*EXACERBATIONS (AECOPD)

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ABSTRACT

AECOPD have major implications on the quality of life, morbidity and mortality of COPD patients. In addition to their assessment on clinical presentation, which can be variable and difficult to predict, a large number of biomarkers are used. Inflammation increases during exacerbations of COPD and there are changes in systemic markers like CRP, IL 6 and PARC/CC18, as well as the cell structure in sputum and blood. The present paper aims at investigating the diagnostic and prognostic value of plasma biomarkers levels, sputum and hematic cell profile in patients with AECOPD. Mean concentration of serum markers studied were higher in first consultation, and significantly decreasing 21 days after. The number of cells in sputum and their structure, number of blood leucocytes has significant differences with results after 21 days. NLR resulted a reliable indicator and simple in the determining of inflammation growth. Diagnosis of AECOPD is supported by increased sputum inflammation and increased systemic inflammation as demonstrated by increased number of blood cells. IL-6, PARC/CCL-18, and CRP resulted useful for diagnosis of AECOPD and to follow-up stabilization. AECOPD inflammation is more evident in stage IV of the diseases.

Keywords: seric marker, CRP, IL-6, PARC/CCL-18, AECOPD

1. INTRODUCTION

Asreporting of symptoms by patients and interpretation by the physicians can be prone to subjectivity, finding more objective criteria for the disease activity would beof crucial importance. Consequently, the use of lab parameters to improve the diagnostic accuracy of acute exacerbation of chronic obstructive pulmonary disease (AECOPD) is a field of interest where studies are advancing.

The present paper aims at investigating the diagnostic value of systemic markers like CRP, IL-6 and PARC/CC18, as well as the cell structure in sputum and blood, in the AECOPD.

2. MATERIALS AND METHODS

This is a prospective study involving 56 patients with AECOPD. 54 (96%) out of 56 patients are men and 29 (52%) of whom are found in stage III and 27 (48%) in stage IV. Anamnestic, clinical and lab data (CRP, IL-6, PARC/CCL-18, cell content of sputum and blood) have been evaluated at first consultation, and after 21days of AECOPD. Characteristics of the patients are in Table 1 reported.

The latex immunoturbidimetric method was applied to determine the CPR. The Cobas C-111, involvingphotometric analysis and an optional unit for the ion selective electrode (ISE) was used to measure the PCR. The evaluation of CRP levels involved thecut off for normal: 5-10, light inflammation: 10-40, active bacterial inflammation: 40-200 and severe bacterial >200mg/l.

Determining Interleukin-6 (IL-6) in serum is used with the immunoassay with electrochemiluminesence “ECLIA” used in Elecsys and Cobas immunoassay analyzer. For evaluating marker IL-6 level, cut off 7 pg/ml was used.

The ELISA kit of CCL-18 (human), an immunosorbent enzyme-linked in vitro test for measuring correctlythe human PARC in serum, plasma and supernatant cell culture, was involved for the PARC/CCL18. The quantitative sandwich enzyme immunoassay technique was applied for testing purposes.

Table 1. Characteristics data of patients

Variable	Mean values ± Std. deviation	Min. value	Max. value
Age	69.3± 7.06	52.00	82.00
Age of smoking initiation	18.3±9.8	0.00	60.00
Cigarette/day	28.3±14.3	0.00	80.00
Smoking years	38.6±14.8	0.00	60.00
Age of smoking initiation	59.3±39.2	0.00	224.00
Duration of cough (yrs)	9.4±5.8	2.00	30.00
Duration of sputum (yrs)	7.96±5.52	1.00	30.00
Duration of dyspnoea (yrs.)	7.2±5.26	1.00	35.00
Recuperative time (days)	7.05±1.86	5.00	12.00
BMI index	25.47±5.09	16.50	48.40
FVC (% predicted)	56.89±11.84	30.00	91.10
FEV1 (% predicted)	36.87±8.57	20.00	50.00
Tiffeneau Index (%)	51.44±9.18	25.40	67.10
SaO2	90.34±3.78	84.00	97.00
CAT score	26.54± 6.8	9.00	35.00
MRC dyspnoea scale	3.52± 0.87	2.00	5.00
Gender	Male	54.00 (96.4%)	
	Female	2.00 (3.6%)	
COPD GOLD stage	Stage III	27.00 (48%)	
	Stage IV	29.00 (52%)	
COPD GOLD category	C3	2.00 (3%)	
	D3	43.00 (77%)	
	D4	11.00 (20%)	
Exacerbation	Type I	32.00 (57.2%)	
	Type II	12.00 (21.4%)	
	Type III	12.00 (21.4%)	

Sysmex XS-100i Automated Haematology Analyzer, involving fluorescent cytometry was used for haematologicalexamination purposes.

The sputum was examined using the material that has been expectorated early in the morning after a deep inhale followed by rough coughing. Once expectorated, itwas stratified in lames, fixed with 95% ethanol, dried and coloured via the Papanikolau coloration. The sputum smearwas examined under the microscope immediately after. If the macrophages are found in sufficient quantity, it is clear that we have to do with sputum, not saliva. If the cellular elements dominating are the squamous cells, candids or even ciliary epithelial cells, we have to do with elements of the oral or sinonasal apparatus. Depending on the dominance of each of the present cellular elements in the smears, based on the normal percentage table of their concentrations as well, the classification of each percentage of the cellular

elements present in the smearwas done. After the percentage of the contents of the cellular elements in the sputum, the cellular structure was classified as neutrophilic, eosinophilic or paucigranulocitic.

Statistical analysis

The data collected were mapped onto Microsoft Excel. Once mapped on to Microsoft Excel, they were exported in SPSS (Statistical Package for Social Sciences) 20.0 and Medstat. In the end, the data were statistically assessed. The values of $P \leq 0.05$ were considered significant.

3. RESULTS

AECOPD has increased significantly of total sputum cells in 39 (69.6%), macrophage -55 (98.2%), neutrophils -51 (91.1%), lymphocytes -37(66.1%), eosinophils -19(33.9%) and epithelial cells -9(16.1%).

Table 2. Sputum cell comparison at AECOPD and 21 days after

Cell structure	Means ± Std. Deviation AECOPD	Means ± Std. Deviation 21 days after	Comparison of means (t-test)
No. of sputum cells	14.4±4.51	8.71±3.52	P<0.0001
Eosinophils [%]	0.83±1.32	0.28±0.059	P<0.0001
Neutrophils [%]	51.63±10.22	31.52±7.44	P<0.0001
Macrophage [%]	33.13±7.12	43.03±7.98	P<0.0001
Lymphocytes[%]	6.71±2.76	9.70±4.50	P<0.0001
Epithelial cells [%]	7.45±3.73	10.34±3.91	P<0.0001

After 21 days of treatment have remained increased total cells in 13 (23.2%), neutrophils -13(23.2%), lymphocytes -45(80%), eosinophils -6(10.7%), epithelial cells -26(46.1%), and totally normal or decreased macrophages.

Table 2 reports that the number of cells in sputum and their structure expressed in percentage in AECOPD has significant differences after 21 days (P<0.0001).

All the AECOPD patients were stratified, according to the number of neutrophils (>61%) and eosinophils (>2.5%) in the sputum samples. Individual patients were classified into the eosinophilic (EO) with sputum

eosinophils >2.5% of total cells, the neutrophilic (NE) with neutrophils >61%, the paucigranulocytic COPD (PA) with eosinophils ≤2.5% and neutrophils ≤61%. Cell sputum stratification resulted: eosinophilic 9(16.1%), neutrophilic 16(28.6%) and paucigranulocytic 31(55.4%) (Table 3).

There were significant differences in number of cells and percent of neutrophils in sputum at AECOPD according to the stage of disease (Table 4).

The average initial blood leukocytosis was 11777± 5233, after 21 days in 2630± 8593 (P<0.0001). AECOPD leukocyte formula (%) and after 21 days resulted respectively: rod nuclear 6.63±3.68 and 2.79±2.51 (P<0.0001), neutrophils 12.38±72.41 and 60.68±10.12 (P<0.0001), eosinophils 2.1±2.69 and 3.81±3.49 (P=0.0045), basophils 0.21±0.27 and 0.22±0.28 (P=0.8478), monocytes 8.15±4.53 and 7.49±3.15 (P=0.3727), lymphocytes 17.07±8.80 and 27.62±8.19 (P<0.0001) (Table 5).

Table 3. Stratification according to cell content in sputum

Stratification according to sputum cells	**No. of cases**	**[%]**
Eosinophilic	9	16.1
Neutrophilic	16	28.6
Paucigranulocitic	31	55.4
Total	56	100.0

Table 4 Sputum cell comparison at AECOPD according to the stage of diseases

Cell structure	**Means ± Std. Deviation stage IV**	**Means ± Std. Deviation stage III**	**Comparisons of means (t-test)**
Nr of sputum cells	16.77±4.18	12.2±3.63	P=0.0001
Eosinophils [%]	0.62±1.23	1.02±1.4	P=0.26
Neutrophils [%]	54.77±10.10	48.7±9.59	P=0.024
Macrophage [%]	31.62±1.17	34.51±6.9	P=0.66
Lymphocytes [%]	6.28±2.52	7.1±2.95	P=0.27
Epithelial cells [%]	7.31±3.95	7.57±3.23	P=0.79

There was increased level of leukocytes in 35 (62.5%) patients, rod nuclear 26 (46.4%), neutrophils 28 (50%), eosinophils 7(12.5), basophils 1(1.8%), monocytes 21(37.5%), and lymphocytes 1(1.8%).

Whereas after 21 days, the leucocyte level has remained increased in 5(8.9%), the stick –1(1.8%), eosinophilic – 13(23%), neutrophilic and basophilic –none, monocytes – 16(28.6%) and lymphocytes – 3(5.4%).

NLR (report neutrophil/lymphocytes) at first consultation and after 21 days have respectively resulted 7.464±12.922 (1.04 - 97.9) and 2.509±1.18 (0.71 - 7.09) (P=0.004).

Table 5 Leukocytic formula at AECOPD and 21 days after

Leukocytic formula	**Means± Std. Deviation AECOPD**	**Means± Std. Deviation 21 days after**	**Comparisons of means (t-test)**
No. of leukocytes	11.777±5.233	8.593±2.630	P<0.0001
Rod nuclear [%]	6.63±3.68	2.79±2.51	P<0.0001
Neutrophils [%]	72.41±12.38	60.68±10.12	P<0.0001
Eosinophilis [%]	2.1±2.69	3.81±3.49	P=0.0045
Basophils [%]	2.1±0.27	2.2±0.28	P=0.8478
Monocytes [%]	8.15±4.53	7.49± 3.15	P=0.3727
Lymphocytes [%]	17.07±8.80	27.62±8.19	P<0.0001

From the results of the haemogram analysis in patients with AECOPD, stage III and IV, significant differences in leukocyte numbers were reported, whereas in cellular structure (expressed in %), there are significant differences between the two stages in the lymfocytes. In the comparison between two groups of disease gravity with the cellular structure groups, there are significant differences (Table 6).

Table 6 Leukocytic formula at AECOPD according to the stage of diseases

Leukocytic formula(10^3)	**Means± Std. Deviation Stage IV**	**Means± Std. Deviation Stage III**	**Comparisons of means (t-test)**
No of leukocytes	13.862±6.594	9.855±2.340	P=0.0033
Rod nuclear	1.11±0.97	1.1±0.93	P= 0.2970
Neutrophils	1.18±0.96	0.96±0.98	P=0.96
Eosinophilis	0.22±0.64	0.27±0.7	P=0.1494
Basophils	7.4±0.38	0	-
Monocytes	0.7±0.95	0.82±1.0	P=0.64
Lymphocytes	0.85±0.36	0.72±0.52	P=0.28

Mean concentration of serum markers studied were higher in first consultation of subjects for AECOPD and significantly decreasing after 21 days (P<0.0001) respectively: IL-$6_0$33.46pg/ml±45.9 (min 3.1 max 232.3), IL-6_{21}9.1pg/ml±7.5 (min 1.7 max 43.6); PARC/CCL-18_0 77ng/ml ±34.5 (min 24.6 max 168.8), PARC/CCL-18_{21}51.2ng/ml ±23.5 (min 10.7 max 107.2); $CRP_0$43.1mg/l ±49.2 (min 0.2 max 257), CRP_{21}11.2mg/l ±12 (min 0.1 max 48). Figure 1 depicts that there is no correlations among these biomarkers with clinical variables.

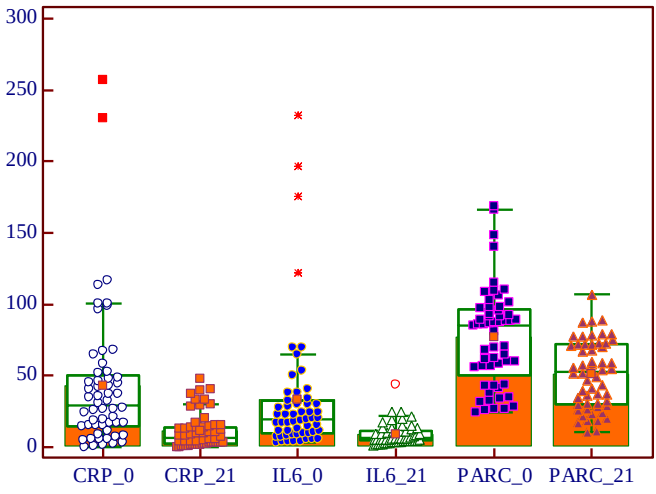

Fig.1. Biomarkers at AECPOD and 21 days after

Levels of CRP, IL6, PARC/CCL18 (cut off 30 and 60 ng/ml) at AECOPD and 21 days after are depicted in the figures 2- 5, respectively.

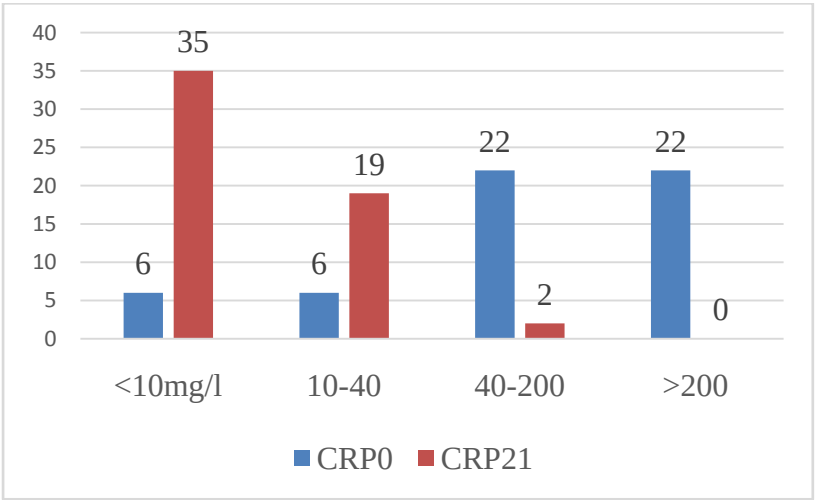

Fig. 2 CRP levels at AECOPD and 21 days after.

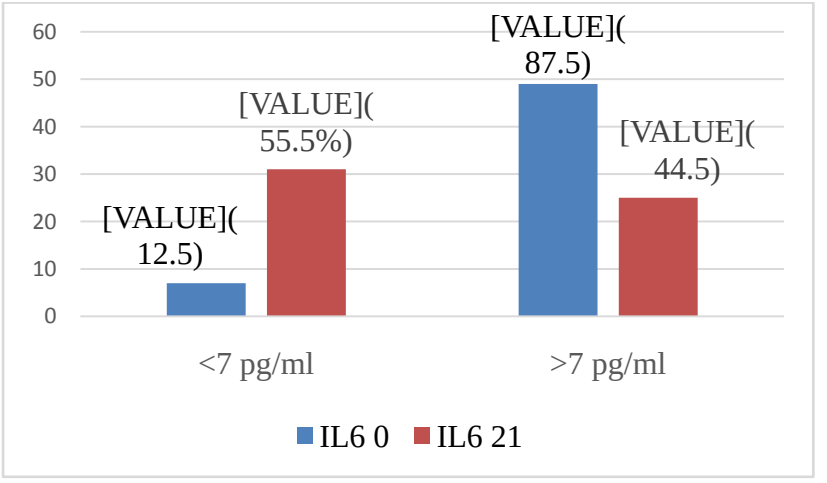

Fig.3. IL6 levels at EACOPD and 21 days after (%)

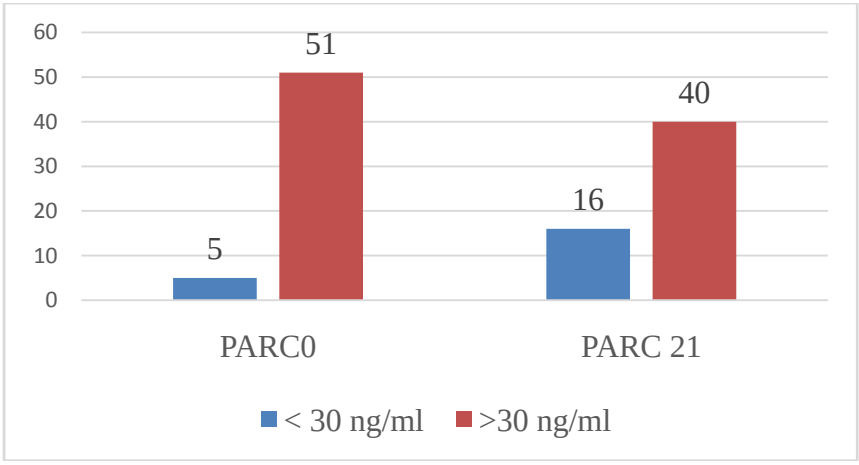

Fig.4 PARC/CCL18 levels at EACOPD and 21 days after (%)

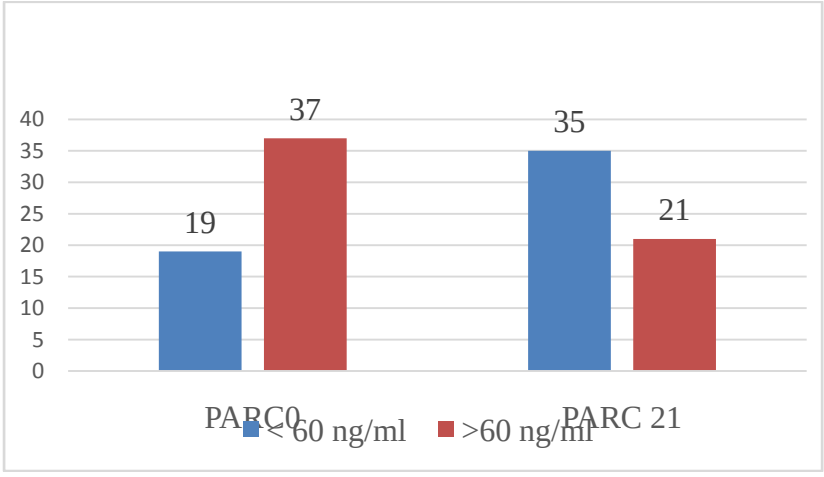

Fig.5 PARC/CCL18 levels at EACOPD and 21 days after (%)

Tables 7-10 report the levels of CRP, IL6, PARC/CCL18 (cut off 30 and 60 ng/ml) at AECOPD according to the category of COPD.

Table 7 CRP levels at AECOPD according to the category of COPD

Category	**CRP 0 mg/l (%)**				**Total**
	5-10	10-40	40-200	> 200	
C3	1(1.8)			1(1.8)	2(3.6)
D3	5(8.9)	5(8.9)	16(28.6)	17(30.4)	43(76.8)
D4		1(1.8)	6(10.7)	4(7.1)	11(19.6)
Total	6(10.7)	6(10.7)	22(39.3)	22(39.3)	56(100)

Table 8 *IL6 levels at AECOPD according to the category of COPD*

Category		IL6 0 pg/ml (%)		Total
		<7	>7	
	C3	1(1.8)	1(1.8)	2(3.6)
	D3	4(7.1)	39(69.6)	43(76.8)
	D4	2(3.6)	9(16.1)	11(19.6)
Total		7(12.5)	49(87.5)	56(100)

Table 9 *PARC levels at AECOPD according to the category of COPD*

Category		PARC0 30 ng/ml (%)		Total
		<30	>30	
	C3		2(3.6)	2(3.6)
	D3	5(8.9)	38(67.9)	43(76.8)
	D4		11(19.6)	11(19.6)
Total		5(8.9)	51(91.1)	56(100)

Table 10 *PARC levels at AECOPD according to the category of COPD*

Category		PARC0 60 ng/ml (%)		Total
		<60	>60	
	C3	1(1.8)	1(1.8)	2(3.6)
	D3	15(26.8)	28(50)	43(76.8)
	D4	3(5.4)	8(14.3)	11(19.6)
Total		19(33.9)	37(66.1)	56(100)

4. DISCUSSIONS

Studies of bronchial inflammation of COPD patients have provided contradictory results. A study with bronchial biopsy resulted in a 30 fold increase of eosinophils, small increases in neutrophils and T-lymphocytes (Saetta *et al*., 1994), whereas in another study with bronchoalveolar lavage, liquid resulted with the neutrophils and eosinophils, but with a more pronounced increase in theneutrophils (Balbi*et al*., 1997). Noninvasive studies of sputum are more easily conducted, but then again results are contradictory: without changes in cell count (Bhowmik*et al*., 2000) or increase in lymphocytes, neutrophils and eosinophils (Fujimoto *et al*., 2005). According to authors, neutrophils results to be connected with the gravity of exacerbations independent of etiology, whereas eosinophilia as an indicator of viral exacerbations (Papi*et al*., 2006).

The present study reported that in 33.9% of cases, there has been an increase of eosinophils and according to the stratification of sputum the eosinophilic type has resulted in 16.1% of the patients. The main presentation during exacerbation of bronchial secretion is increased neutrophils(Balbi*et al*., 1997), which resulted even in our study, where the cellular profile of sputum together with the neutrophilic (28.6%) and paucigranulocitic (55.4%) results in 84% of the cases, which is connected even with the appearance of change of purulence in sputum(Stockley*et al*., 2001).

From our data, after 21 days of exacerbation, in the sputum there is a decrease in the number of total cells, a decrease in the neutrophils and eosinophils percentage, as well as an increase in percentage of lymphocytes. The cell count in sputum as well as their structure expressed in percentage in AECOPD has significant differences with the results after 21 days ($P<0.0001$). As it results even from our data, at the time of the exacerbation remission, there is a decrease in the number of neutrophils, which is related to the eradication of the bacteria from the sputum (White*et al*., 2003). During a

COPD exacerbation, great observing studies haven't shown a significant increase of macrophages in sputum, or the bronchial tissues, even as a percentage of the total cell and neither as an absolute increment of cells (Bhowmik*et al*., 2002; Papi *et al*., 2006). In our study the result is different – an increase of macrophages in the exacerbation.

There has been a significant difference in the average number of blood leucocytes in AECOPD and 21 days after (P<0.0001). Just so, the leucocytary formula (%) in AECOPD and after 21 days results in a significant drop of rod nuclear (P<0.0001), neutrophils (P<0.0001), an increase of eosinophils (P=0.0045) and of lymphocytes (P<0.0001). With the improvement of the exacerbations there is a significant decrease of the leucocyte numbers, mainly as a consequence of the neutrophils dropping.The number of neutrophils in blood increases with the systemic inflammation. The increased number of neutrophils is connected to the progression of COPD (Sinden*et al*., 2010). Our data match the ones from the studies where the leucocyte levels have resulted with significant statistically increase in the patients with COPD exacerbations, compared to the ones in remission.

Our results suggest that matching the literature, the NLR can be considered like a reliable indicator and simple in the determining of inflammation growth in patients with COPD. Furthermore, NLR can be useful for discovering early acute exacerbations that are possible in COPD patients (İn *et al*., 2016).

The level of biomarkers studied in the AECOPD, and after 21 days of treatment has resulted in a significant difference which shows their value in exacerbation evaluation of COPD. The levels of markers resulted higher at the first consultation of subjects for AECOPD, and there is a notable decrease after 21 days (P<0.0001).

CRP is the most well known marker. High levels of systemic CRP have been found connected to the increase of disease gravity, worsening of health condition, hospitalization and mortality in COPD (Broekhuizen*et al*., 2006). CRP was the first biomarker to be studied in COPD. Most of the studies have indicated that CRP levels are increased in these patients (de Torres *et al*., 2008). A study showed that CRP levels testing in patients with lower respiratory system infections in primary care has reduced antimicrobial prescriptions considerable, without compromising the recovery of the patient (Cals*et al*., 2009). From literature, CRP testing was insignificantly sensible and neither was it specific enough to distinguish an infiltrate in thoracic radiography, and the bacterial etiology of the infection of the lower respiratory tract (van der Meer*et al*., 2005). In the biomarkers field, the measuring of the procalcitonine levels looks promising as a tool to identify patients with COPD exacerbations, which demand antimicrobial treatment (Stolz *et al*., 2007).

Levels of IL6 in exacerbations and after 21 days in relation to the value over cut off- 7pg/ml, resulted with significant difference, which speaks of the value of application in the discovery of exacerbationand the follow-uptheinflammation in patients with AECOPD.

PARC/CCL-18 in AECOPD has a significant difference with that after 21 days. There has been research conducted: "Lung Health Study (LHS)" for PARC/CCL-18 in COPD, where different populations of COPD are included, 4800 subjects with light or moderate COPD, 1800 subjects of COPD from the ECLIPSE study, which represent all the GOLD stages, 312 smokers and 226 non-smoking controls, and 89 COPD subjects with prednisolone treatment (Sin*et al*., 2011). Results were somewhat contradictory.

In the LHS, high levels of PARC/CCL-18 were connected with lower FEV1, increased cardiovascular mortality rate. In ECLIPSE study, levels of PARC/CCL-18 were higher on individuals with COPD than in the control group, but there was no correlation with FEV1.

According to cell stratification in sputum, there results that in the exacerbations, with the increase of CRP levels, there is an increase in the neutrophilic and paucigranulocitic groups. In the examination of sputum after 21 days, it is noted that, in relation to the drop in CRP levels, there is a drop of the neutrophilic group, and paucigranulocitic. In the measurements blood level of IL-6, classified in value <7pg/ml and as an increased level, values >7pg/ml, results that in sputum there is a larger neutrophilic and paucigranulocitic in the patients with IL6>7pg/ml. After 21 days, it results that the decrease of IL-6 levels is accompanied with a change of cellular structures, with a decrease of neutrophilic and paucigranulocitic groupings. In the definition of PARC, as in cut off 30ng/ml and 60ng/ml there is a correlation between the increases of marker levels with the paucogranulocitic group. Parameters such as the level of serial CRP, value of ESR, number of leucocytes and predomination of neutrophils in the leucocitary formula, are used quite often to follow the infection in clinical practice. Different marker levels as in the CRP inflammation, fibrinogen and leucocyte counts are increased in patients with COPD in the period of exacerbations (Dentener*et al*., 2001).

Liang *et al*., (2015) studied correlation between changed in CRP levels and resolution of bronchial inflammatory markers, and of clinical health state during the period of recovery, after an acute COPD exacerbations. The relation between changes in bronchial inflammatory markers, the CAT and CRP results during the recovery period was studied. Serial levels of CRP in the acceptance of patients in hospitals with negative prognosis have been higher than the ones without it. In comparison with patients without cardiovascular complications, patients with them had higher serial levels of CRP on acceptance. The drop of CRP levels correlated positively with the

decrease of neutrophils in sputum in the fourth and seventh days. There has been a significant correlation between drop of CRP and CAT. Thus, the authors reach the conclusion that CRP could be useful in monitoring the resolution of bronchial inflammation and improvement of health state during the treatment of COPD exacerbations.

COPD exacerbations caused by bacterial infections have an increase of neutrophils in sputum, often causing a systemic inflammatory reaction: inflammatory markers such as the neutrophil blood count, CRP, fibrinogen and IL-6 in serum, are increased during the exacerbations (Hurst*et al*., 2006).There have been several mechanisms, proposed as the origin of systemic inflammation increase. These include: 1) expression of inflammatory mediators from pulmonary structures; 2) inflammatory reaction in tissue hypoxia; 3) reaction, induced by pro-inflammatory bacterial lipopolysaccharide products (Wouters*et al*., 2005).

From the haemogram analysis results in stage III and IV AECOPD patients, there can be seen significant differences in leucocyte numbers, whereas in cellular structures (expressed in %), there are significant changes between the two stages of lymphocytes. In comparison between the two disease gravity groups, according to the groups of cellular structure, resulting in significant changes. If we compare inflammation intensity (after the grouping of CRP values) initialy and after 21 days in exacerbated COPD of stages III and IV, the inflammation results to have been more pronounced in stage IV and in both periods. In comparison with the initialy IL6 values and after 21 days in stage III and IV of exacerbated CPD, there appear to be higher level in stage IV and both periods, but the difference is more pronounced in the measuring after 21 days. According to the COPD stages, values of initially PARC are more pronounced in stage IV, more evident for cut off 60. In relation to initially CRP in normal values, there are no category D4 cases and greater values of the level from 40 to over 200 mg/l are in relations to categories D3 and D4. In the results of examinations after 21 days, it is noted that cases are collected in CRP levels below 40 mg/l.

5. CONCLUSIONS

Diagnosis of AECOPD is supported by increased sputum inflammation as proxy of airways inflammation and increased systemic inflammation as demonstrated by increased number of blood cells. IL-6, PARC/CCL-18, and CRP resulted useful for diagnosis of ECOPD and to follow-up stabilization. AECOPD inflammation is more evident in stage IV of the disease.

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INFLUENCE OF LINEAR DENSITY AND CROSS SECTION SHAPE OF THE MONOFILAMENTS ON THEIR BENDING BEHAVIOUR

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ABSTRACT

The present paper provides information about the bending behaviour of Low Linear Density Polyethylene (LLDPE) monofilaments used in artificial turf systems. This behaviour is based on two of the physical properties of the monofilaments such as linear density and cross section shape. Six different fibres were in the present investigation involved and two test methods were applied to measure the bending force. The results reported that the maximum values of the bending force are mostly influenced by the monofilaments cross section shape and less by their linear density. Both methods show the same trends regarding this influence on the fibres bending behaviour.
***Keywords*:** bending force, cross section, linear density, Favimat R, DMA

1. INTRODUCTION

The performance of artificial turf is of primary concern to the long term service and quality. Artificial turf has different layers (Schoukens 2009; Sandkuehler *et al*., 2010). Based on the production process, the pile layer is

the key for long term performance (Joosten 2003) as it consists of LLDPE fibres which are fixed on the backing part of the product — the carpet (Schoukens 2009). The fibres are fixed through the coating process. Here, the carpet undergoes a heating process which brings the fibres to a temperature at 80°C (EN Standard prEN15330-1 2006).

Among several properties, determining the performance of the final product, the ability of the pile layer to stand different deformation forces is the most discussed property (Kolgjini *et. al*., 2012; Kolgjini 2012). These because the pile layer has a direct impact on ball roll distance and ball rebound (FIFA), and also it influences on the performance of the players (Joosten 2003). The force that mostly influences the deformation of the fibres is the bending force (Schoukens 2009).

The present paper provides some information about the bending force of monofilaments by changing at the same time physical parameters (the linear density (finesses) and the cross section shape for the same polymeric material (LLDPE)).

2. MATERIALS AND METHODS

Materials

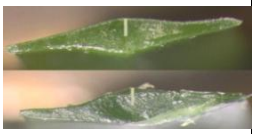
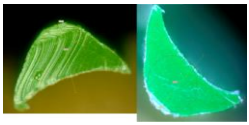
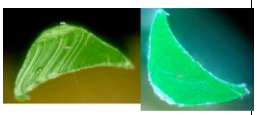
Six different fibers were involved in the testing program. All the fibers are linear low density polyethylene (LLDPE) which are used in the artificial turf as pile layer.

The fibers were selected randomly and they have different dimensional characteristics in terms of linear density and cross section shape. Information about the production methods and processing parameters of the testing fibers lacked.

Fibers were heat treated for one hour at 80^0C to be in the same conditions they are after the carpet is produced (EN Standard prEN15330-1 2006). The linear density was measured for the six fibers and the resulting values in terms of Tex are in Table 1 reported along with the images of the cross section of each fiber. Both linear density and cross section were measured at the laboratories of the Department of Textile, Ghent University, Belgium, under standard conditions.

Both fiber A and B are diamond-shaped fibers, but slightly different in the extension of the sides. In addition, their linear density is different. Fiber B and F are almost “c” section, but to be noticed is that the shape of the “c” is different from one another. Fiber F has a kind of a small ball on one side and the “c” is hollower than in fiber B. The “c” shape has two sides: the concave and the convex side. The last two fibers are of different shapes, where fiber C is almost rectangular shaped, while fiber D has a small ball in the center.

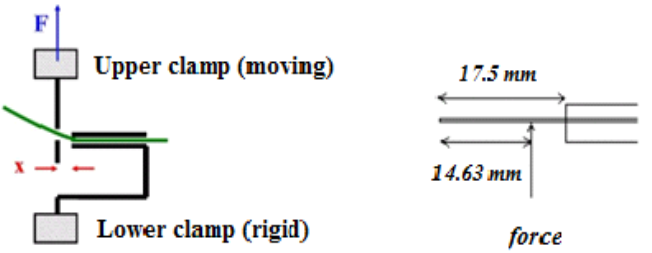
Table 1. The linear density and cross section for the testing fibers

LLDPE Fiber sample	Linear Density Tex (g/km)	Cross-Sectional Shape	LLDPE Fiber sample	Linear Density Tex (g/km)	Cross-Sectional Shape
A	205		D	208	
B concave B (l)	225		E	225	
B convex B (m)			F concave F (l)	206	
C	149		F convex F (m)		

Test methods

Two different test methods were applied. The first test method was carried out in the FAVIMAT R (Textechno). This is a dynamic bending test performed regarding the Standard PM 1301established by the Ghent University. The usual set up of the instrument (for tensile testing on one single filament) was modified (see Fig. 1a) to be able to test the bending force of one monofilament.

The method relates to the flexing of the free side of a single filament. One side of the filament is clamped, while the other free side is subjected 300 times to a perpendicular force. The distance from the clamping point and the flexing point is 2.87*mm*. Here, the force is applied. The filament has a free length of 17.5 *mm* (see Fig. 1b), which corresponds to the average free pile length in the artificial turf system.



a) b)

Fig. 1.a) Schematic presentation of the bending test on Favimat R and b) test setup (University of Gent Standard PM 1301).

The preload force applied is 0.01 *cN* and the test speed is 100*mm/min*. The minimum deflection is 2 *mm* while the maximum is 8.0 *mm*. The force needed to cause the deflection is monitored in both advancing and receding part of each cycle. For each fiber are performed 4 tests. The total duration for one repetition is 40 minutes.

Fibers B and F are tested in both sides of the "c" shape, the concave side denoted as (l) and the convex side denoted as (m), because the fiber performs differently in each of the sides. The testing conditions are 23°C and 65 % R.H. For each cycle is measured the maximum force and the results for the 300 cycles are displayed in a table (see Table 2) and a graphic (see Fig. 2) from the FAVIMAT program. The same table and graph is obtained for each fiber separately.

Table 2. Maximum bending force (for fiber A) for each cycle (1÷300) in Favimat testing.

Test:	**1**	**2**	**3**	**4**	**Mean**	**1**	**2**	**3**	**4**	**Mean**
Cycle	F (cN)	F (cN)	F (cN)	F (cN)	**F (cN)**	**F (%)**	**F (%)**	**F (%)**	**F (%)**	**F (%)**
1	2.527	2.276	4.043	3.576	**3.106**	100.0	100.0	100.0	100.0	**100.0**
2	1.716	1.536	2.311	2.263	**1.957**	67.9	67.5	57.2	63.3	**63.0**
3	1.573	1.431	2.125	2.062	**1.798**	62.2	62.8	52.6	57.7	**57.9**
4	1.506	1.366	2.037	1.967	**1.719**	59.6	60.0	50.4	55.0	**55.3**
5	1.46	1.323	1.978	1.888	**1.662**	57.8	58.1	48.9	52.8	**53.5**
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
100	1.176	1.061	1.544	1.472	**1.313**	46.5	46.6	38.2	41.2	**42.3**
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
299	1.144	0.98	1.44	1.357	**1.230**	45.3	43.1	35.6	38.0	**39.6**
300	1.143	0.981	1.443	1.357	**1.231**	45.2	43.1	35.7	37.9	**39.6**

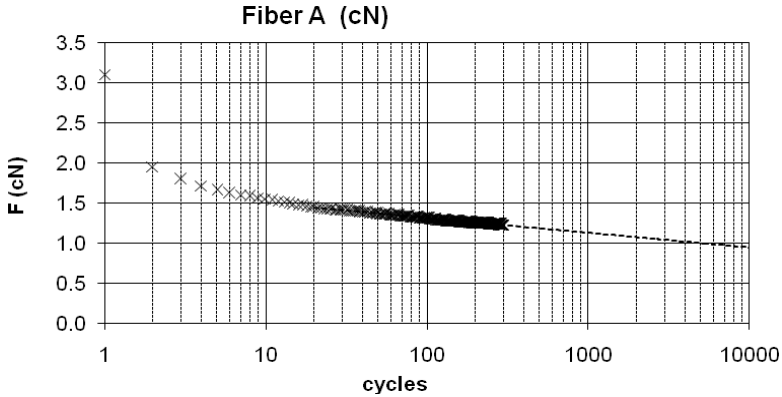


Fig. 2. The measured bending force (for fiber A) in function of the number of cycles in the Favimat.

The second test method was performed in the DMA (Dynamic Mechanical Analyzer) TA Instrument. Here, the DMA instrument was modified to measure the bending at the Department of Textile, Ghent University. The DMA is set to Controlled Force Mode (Menard 2008) and the distance of applying the force is set to 2 *mm* and 2.9 *mm*. The detailed information is restricted from the University of Gent. In this test, the bending force is measured for a single monofilament.

For each fiber were performed 3 repetitions. The testing is carried out at room temperature, which corresponds to 23 $\pm 2^0$C. Fiber B and F were tested in both sides, for the same reasons as in FAVIMAT R. The TA Instruments Universal Analysis (UA) Program (Universal Analysis 2000) was used for data analyses. For the 3 measurements of each fiber, the static bending force (N) is plotted versus the displacement (μm). The Onset Point (OP) 1 and Onset Point (OP) 2 were found in each graphic, through the UA Program (see Fig. 3) and the mean value is calculated. The same plot as below is obtained for each repetition of each sample.

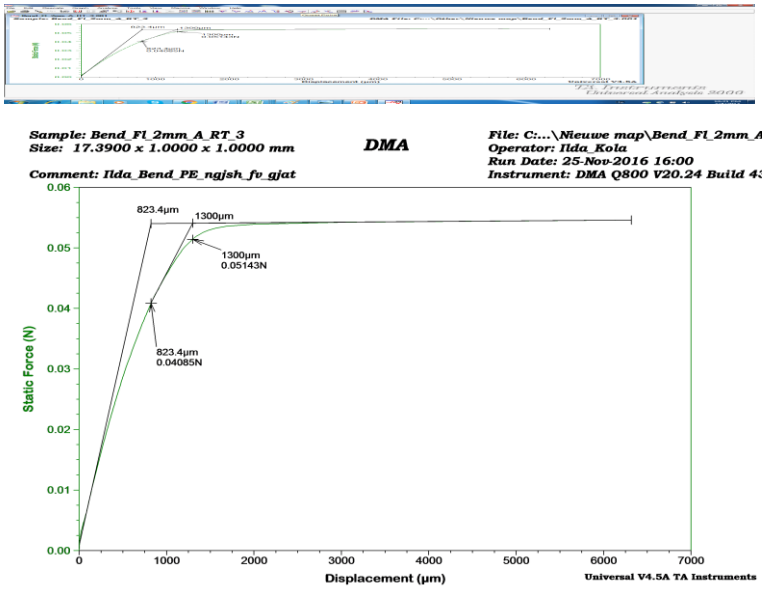


Fig. 3. The bending force of fiber A versus displacement and the Onset Points on the DMA.

3. RESULTS AND DISCUSSIONS

The measured bending forces of each fiber resulting from the FAVIMAT R testing, as shown in the test method paragraph (see Table 2), are in Table 3 reported along with the standard deviation. The cycles 1, 100 and 300 are taken into consideration.

Table 3. Maximum bending force and the standard deviation measured in FAVIMAT R.

	Cycle 1		**Cycle 100**		**Cycle 300**	
Fiber Sample	**Average F (cN)**	St dev F (cN)	**Average F (cN)**	St dev F (cN)	**Average F (cN)**	St dev F (cN)
Fiber A	**3.106**	0.841	**1.313**	0.231	**1.231**	0.209
Fiber B(l)	**3.982**	1.024	**2.215**	0.945	**2.116**	0.94
Fiber B(m)	**4.798**	0.918	**2.392**	0.494	**2.28**	0.462
Fiber C	**1.517**	0.673	**0.737**	0.392	**0.691**	0.369
Fiber D	**1.702**	0.276	**0.868**	0.111	**0.823**	0.108
Fiber E	**3.343**	0.396	**1.276**	0.27	**1.204**	0.253
Fiber F(l)	**3.278**	0.788	**1.167**	0.275	**1.107**	0.257
Fiber F(m)	**4.982**	0.688	**2.061**	0.261	**1.945**	0.24

The data in the Table 3 show different bending forces for all fibers. The force decreases as the number of cycles increases. The decrease in the first

cycles is significant, while the decrease after 100 cycles becomes smoother until it stays almost constant for the last cycles as reported in (Kolgjini *et al*., 2009). Also, the fibers B and F show the difference on the bending force of each side. Both fibers show a higher value on the convex (m) side.

To have a better view on the assessment of the influence of linear density and cross section shape of the fibers on their bending behavior, the maximum bending force for the selected cycles is plotted versus the fiber's sample and the respective linear density in terms of Tex (*g/km*) as it presented in the Chart 4. Fiber sample and the cross section shape are closely related.

The chart shows that both "c" shaped fibers, B and F, perform better than all the other fibers, especially in the convex (m) side. The values of the bending force are very similar on this side, showing a very small difference in favor of fiber F for the first cycle, while it reverses on cycles 100 and 300 in favor of fiber B. This similarity is not affected from the linear density of the fibers, which is slightly different. This can be explained with the shape of "c", which is very similar in the convex side for both fibers. On the other hand, the chart shows a more significant difference on the bending force measured for the concave side (l) of the fibers B and F (see Fig. 4). The fiber B shows a higher value of the bending force in this side and this may be resulting from the difference that the fibers have on the shape of "c" on this side. The table 1 clearly reports the difference. Fiber F has a hollower shape on the concave side than fiber B.

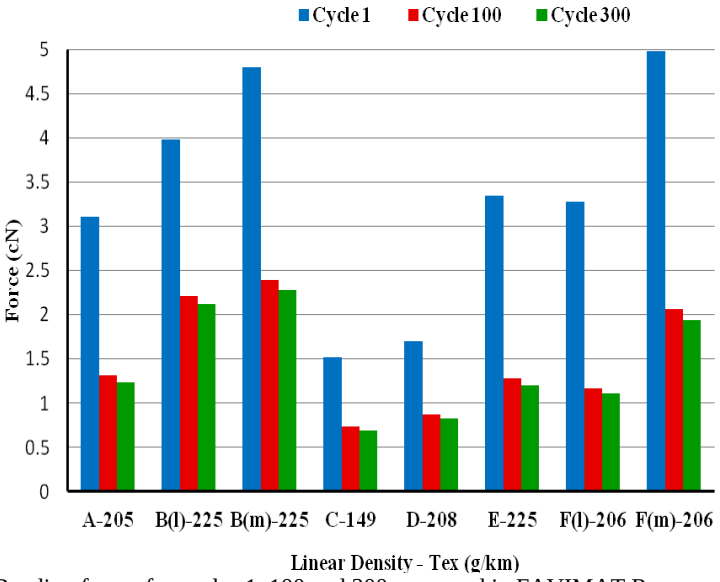


Fig. 4 Bending forces for cycles 1, 100 and 300 measured in FAVIMAT R versus Linear Density (Tex) of the tested fibers.

In addition, it is reported that fiber A and E have similar shape of the cross section. They are both diamond shaped, but slightly different, with fiber A being more extended on the sides than E. In addition, their linear density has almost the same difference as fiber B and F. The chart shows that both fibers have a very similar performance, with a small difference in favor of fiber E on the bending force measured for cycle 1, which becomes insignificant on cycles 100 and 300 (see Fig. 4).

The two last fibers to be considered are the fiber C and F. Their bending force for both fibers is much lower than the others. Although they have a considerable difference on their linear density, with fiber D being thicker, the force is slightly higher for fiber D, for the three cycles. This may be dedicated mostly to the shape of the cross section, which is rectangular for fiber C, and kind of a rectangular with a small ball in the center (see Table 1).

If is considered only the linear density, the chart shows that fibers with very similar, or the same Tex, perform differently. Therefore, fiber A, D and F, with linear density (Tex) of 205, 208 and 206, respectively, have different values of the bending forces. The chart plots different performance on bending for the fiber B and E, regardless the same linear density of 225.

The results of the bending forces measured on the DMA, more precisely the Onset Points 1 and 2, are extracted from the UA Program, as shown on the test methods paragraph. The mean values, calculated for each fiber, are summarized in Table 4. In this analysis are considered both distances of applying the force 2 mm and 2.9 mm.

Table 4. Bending static force measured in the DMA. Onset Points (OP) 1 and 2.

Fiber Sample	**Point of applying the force**			
	2mm		2.9mm	
	OP 1 (cN)	**OP 2 (cN)**	**OP 1 (cN)**	**OP 2 (cN)**
Fiber A	4.213	5.039	2.252	2.899
Fiber B(l)	4.652	6.779	2.775	3.799
Fiber B(m)	7.817	8.801	3.947	4.746
Fiber C	2.109	2.604	1.546	1.955
Fiber D	2.907	3.715	1.511	2.015
Fiber E	4.747	5.756	2.968	3.54
Fiber F(l)	4.297	5.526	2.572	3.683
Fiber F(m)	6.109	7.768	4.795	6.04

The results in Table 4 show different values of the Onset Points 1 and 2 for all fibers. To be noticed is the difference on these values, when the distance of applying the force changes from 2 to 2.9mm. To have a better view on the

influence of this distance, the fiber's samples and their respective linear densities are plotted versus the Onset Points (1 and 2) for both distances (see Fig. 5 and 6). Both charts clearly the difference on the force values related to the distance of where the force is applied. As it could be noted, the Onset Points (1 and 2) have higher values in the 2mm distance—as for all the samples. The difference on the forces for each distance might be different for each fiber, and also from OP 1 to OP 2.

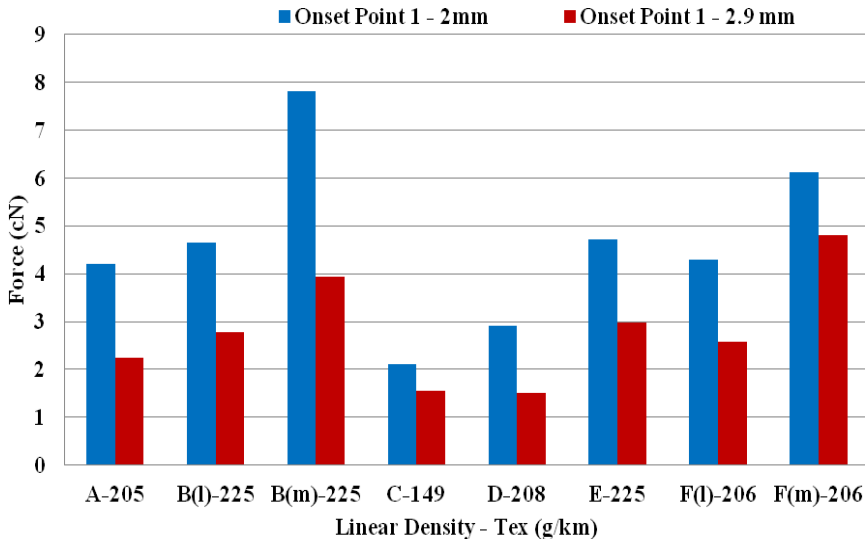


Fig. 5. Bending forces (Onset Point 1) applied in both distances (2 and 2.9*mm*) on DMA versus Linear Density (Tex) of the tested fibers

The highest values in the charts belong to the "c"-shaped fiber B and F on their convex side (m)-analogue with the Favimat results, but in this case the difference in the force between the fibers is higher. Staying in the same discussion, fiber B shows a higher force on the concave side (l) than fiber F, difference that is more noticeable on the 2 mm distance and reduces on the 2.9 mm. The behavior of these two fibers on both sides may be explained from the same reasons as above.

The chats show that the diamond shaped fibers, A and E, have similar force values, with fiber E performing a bit better than A. This can be noticed in both distances and both onset Points.

Fiber C and D, in analogy with the Favimat results, show the lowest values among all fibers. Fiber D has a slightly higher value than C on the 2 *mm* distance, difference that becomes insignificant in the 2.9 *mm* for both Onset Points.

Considering only the linear density, there is no correlation between the Tex value and the bending force. The only remark is that the fiber C with the lowest Tex, which is the finest one, shows the lowest values of the bending force in all cases.

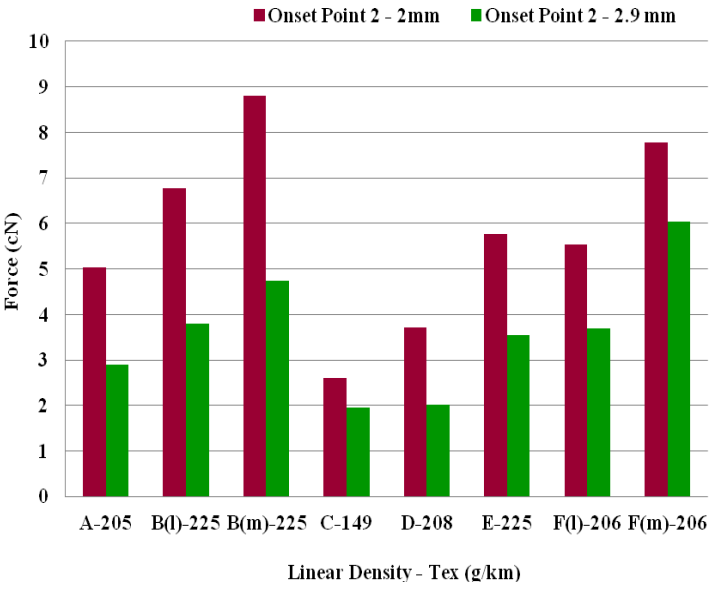


Fig. 6. Bending forces (Onset Point 2) applied in both distances (2 and 2.9*mm*) on DMA versus Linear Density (Tex) of the tested fibers.

The results obtained from Favimat and DMA were overlaid for a better data interpretation regarding fibers performance in both testing methods. So, bending forces for the Favimat Cycle 1, DMA Onset Point 1 - 2 mm and Onset Point 1- 2.9 mm is plotted versus the fibers Linear Density the (see Fig. 7). The graph reports that the trend of the force values, for the respective fibers, is the same, including both distances in the DMA. The trend is the same for the fiber B and F which have the highest force values, fiber A and E which have similar force values, but lower that the aforementioned fibers and for the C and D which have the lowest force values.

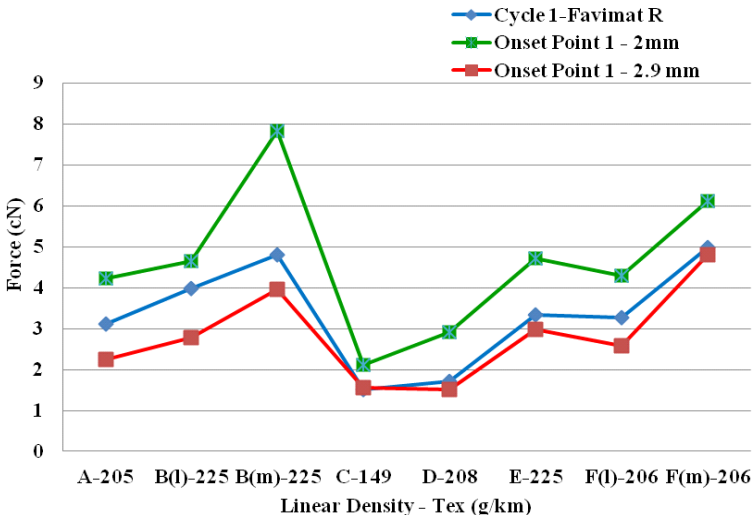


Fig. 7. Bending forces for Favimat and DMA testing versus Linear Density (Tex) of the tested fibers.

4. CONCLUSIONS

The present paper aims at investigating the influence of the physical properties such as linear density and cross section shape on the bending force. Six different fibers were involved and two test methods were applied. Results reported that fibers bending force is related to the cross section shape. The "c" shaped fibers tested on the convex side, have the highest values of the bending forces followed by the diamond shaped fibers which have a very similar performance. The rectangular-shaped fibers have the lowest values.

Considering the linear density of the fibers, the results showed that the Tex value and the bending force are not correlated. The fiber with the lowest Tex, which is the finest one, showed the lowest values of the bending force among all fibers.

For both testing methods used, the trend of the bending force values for the respective fibers is the same.

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STRUCTURE ANALYSES OF RECYCLEDRUBBER BY USING VIBRATIONINFRA RED SPECTROSCOPYMETHOD, EQUIPPED WITH ATR SYSTEM

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ABSTRACT

The present paper aims to investigate the structure and the content of recycled tires used in artificial turf/ grass as infill materials applying the spectroscopy method with vibration infrared and the Fourier FTIR transformation equipped with ATR system, a method which enables analysis of samples of thick surface, without any prior preparation. The scanning of samples was performed in range of wavelength from 4000-400 cm^{-1}. Results reported that the basic material and the fillers were distinguishable and the changes in the micro-structure of the tires could be seen using the SEM analyses.
***Keywords**:* Synthetic Rubber, FTIR-ATR, SEM-EDS, structural investigation

1. INTRODUCTION

The rubber industry began when Charles Goodyear invented the first usable mixed rubber: natural rubber plus sulfur. The concept of mixing rubber materials to improve the performance is still of primary importance today (Turer 2012).

Rubber can be produced both naturally, through the latex found in certain plants; and synthetically, through a process that uses unsaturated hydrocarbons. In addition, rubber is a polymeric material widely used in the automotive industry(Niyogi 2007). Flexibility and stability are the most characteristic features of this material. Chemical construction and physical state of rubber depends on carbon bond which can be coiled or complex. The high elasticity of rubber depends on the ability of these connections to

organize and pull. Due to the extreme prevalence of rubber products the tires are discarded and rubber recycling has become more common (Adamiak 2012).

Rubber can be recycled using one of three basic methods: by reusing (retreading old tires produces functional refurbished tires). By burning; tires produce energy used for different purposes (Turer 2012). By chopping down and forming an entirely new product, such as playground surfacing or using them directly as infill material especially in artificial turf. This group of recycled rubbers will be the focus of our study (David 2007).

By using rubber particles in applications such as soccer fields offers several benefits, including decreasing and sports injuries. Advantages in artificial terrain lie in rubber ability to withstand aggravated climatic conditions, even during or immediately after a rain storm (Alessandria*et al.*, 2013).

The granulated rubbers used as infill material for artificial turf are recycled mostly from the tires of cars and trucks (March 2008). These tires are supposed to be abrasion resistance, aging resistance, temperature resistance, resistance to oxygen and chemicals therefore are added fillers like carbon black during vulcanization with sulfur (Alessandria *et al*.,2013). As such it is very important to know what kind of additives they have. Therefore, the present paper aims to investigate the components of granulated rubbers used in artificial turf. The samples were randomly chosen from different fields and for investigations are used two different test methods; the Infra-Red spectroscopy by Fourier Transform FT-IR ATR and Scanning Electronic Microscope (SEM).

2. MATERIALS

The present investigation involved eight granulated rubbers from different football fields being used as fillers in artificial grass football fields, received by Albanian and foreign market. Information about color, shape and size of the samples is in the Table 1 reported.

Table 1 Studying rubber sample

Sample	G-1	G-2	G-3	G-4	G-5	G-6	G-7	G-8
Color	White	Green	Black	Black	Black	Black	Black	Black
Shape	Granule 2.5mm	Granule 0.8mm	Granule 0.8mm	Granule 0.8mm	Granule 0.8mm	Granule 2.0mm	Granule 1.mm	Granule Fine

3. Test Methods

Infra-Red spectroscopy by Fourier Transform FT-IR ATR

Figure 1 depicts the Spectrometer Bruker Tensor 27 which is equipped with Platinum ATR. The spectrometer enables the analysis of thin samples without any prior preparation. Instrument resolution was 4cm-1. Wave number interval was measured from 370 to 4000cm-1. Number of accumulations to reduce the noise was 10. The OPUS software and abundant data about rubbers were a means to addressstructural analyses and filler identification.

The principle of the FTIR technique is that light introduced into a suitable prism at an angle exceeding the critical angle for internal reflection develops an evanescent wave (a special type of electromagnetic radiation) at the reflecting surface. Interaction of this evanescent wave with the sample determines ATR spectrum recording.

The main characteristics of this techniques is the fact that particle samples are deposited on the surface of a horizontal ATR crystal for spectroscopic analysis (Maria 2012; Mario *et. al*., 2012)

Fig. 1. Spectrometer Brucker Tensor 27 ATR device system.

Scanning Electronic Microscope (SEM)

SEM is equipped with a X-ray microanalysis system (EDS of Oxford Instruments). EDS stands for “Energy Dispersive Spectroscopy” and it is based on X-rays emitted from a sample during electron irradiation. With this instrument chemical analysis, either qualitative or quantitative, can be performed (Michler 2008; Guise *et al.,* 2011). In this case, only qualitative analyses are given because additives are impregnated in the polymeric material and mixed analyses cannot be avoided.

4. RESULTS

The received spectrum, presented respectively for the tested samples,is a two-dimensional plot in which the axes are represented by intensity and frequency of sample absorption. The frequencies are helpful for the

identification of the sample's chemical make-up as the chemical functional groups are responsible for the absorption of radiation at different frequencies. The concentration of component can be determined based on the intensity of absorption.

For the first sample of rubber, named G-1, the two main components seem to be Polystyrene butadiene ABA Block (28% Styryne) Kraton D 1101 presented with the molecular formula (C4H6) x (C8H8) n, and Rubber carbon filled. The identification and the molecular formula are found directly from the library of the OPUS software. In each sample, the spectra are accompanied by the name of the compound of the presented elements (see figure 2 to 9).

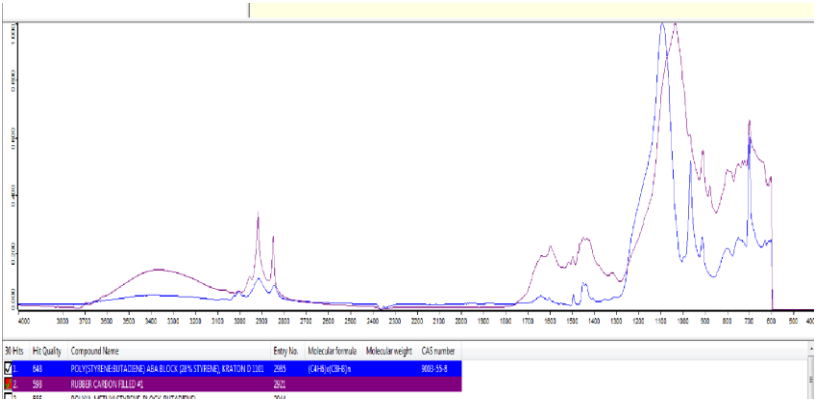

Fig.2. IR spectrum of artificial rubber G-1

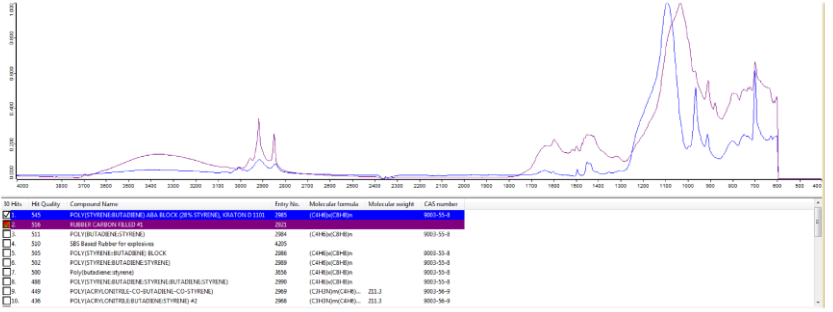

Fig.3.IR spectrum of artificial rubber G-2.

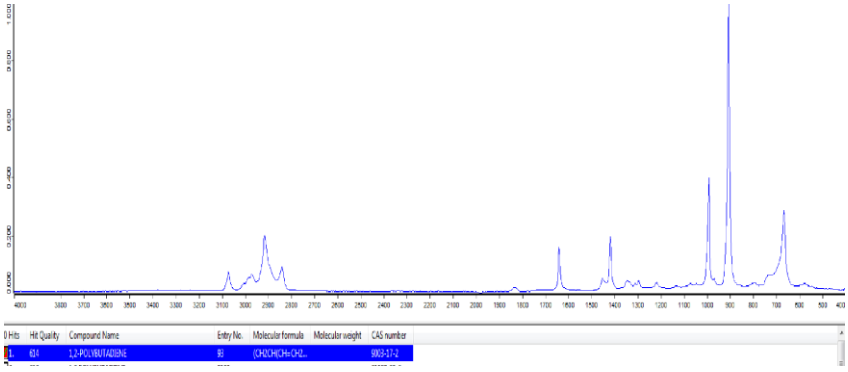

Fig.4. IR Spectra of artificial rubber G-3.

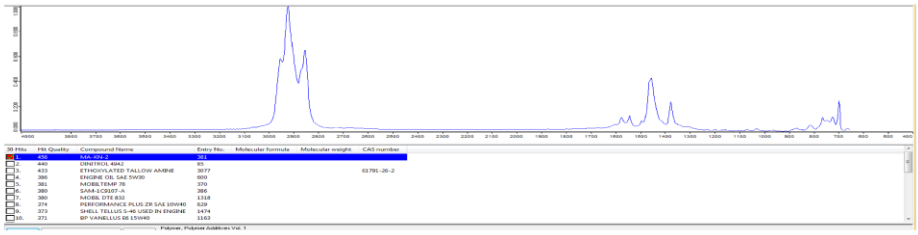

Fig. 5. IR Spectra of artificial rubber G-4.

Note the presence of different peaks other than that of rubber with small intensity, which indicates the presence of fillers in them. Accurate identification of fillers would be difficult due to their low intensity. Nevertheless, a lot of fillers in the library appear with their commercial names or the name of the manufacturing company, e.g., MA-KN-2—observable in the G-4.

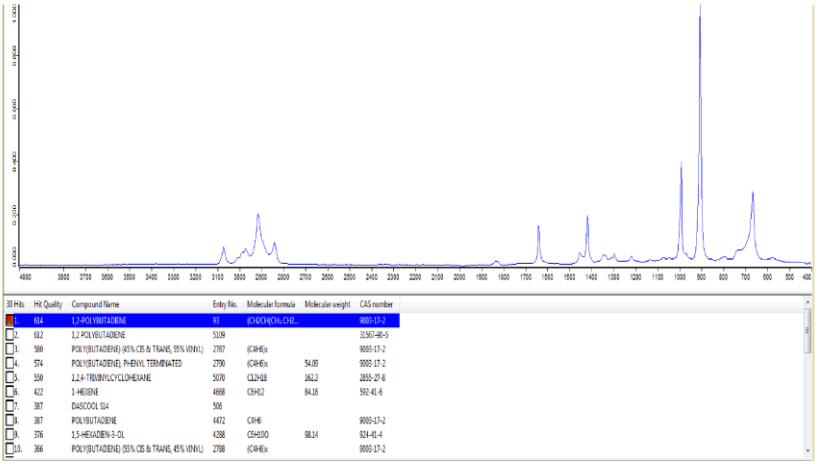

Fig.6. IR Spectra of artificial rubber G-5.

Visible spectra showed the vibrating rubber G–5curves. The low intensity of peaks made the identification of the fillers difficult. In the end, the commercial name Paramo Prenol PP44, a chemical mixture consisting of butyl and polysulfideBruker Optik GmbH OPUS (Reference Manual version 5 (page 162-163)) was determined.

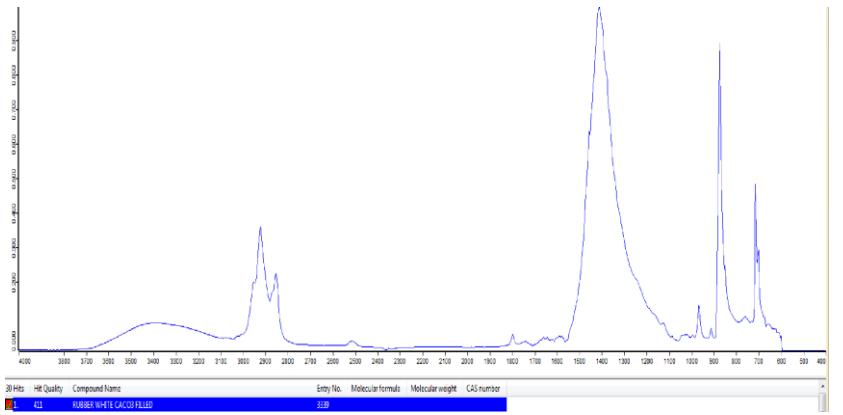

Fig.7. IR Spectra of artificial rubber G-6.

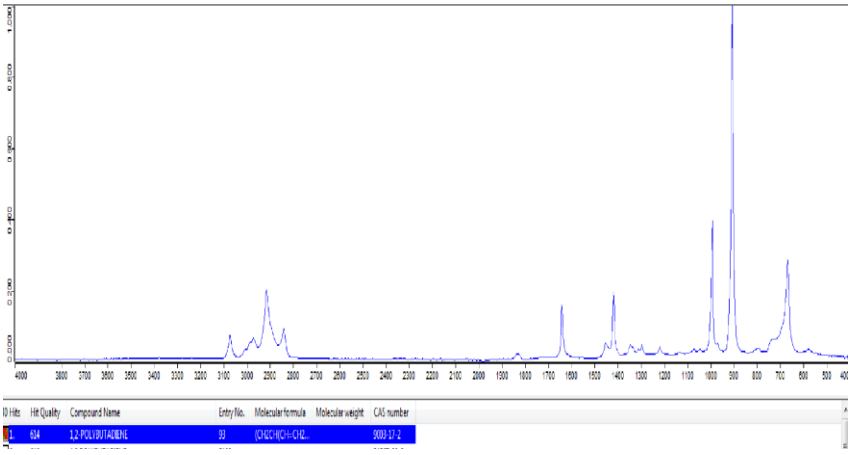

Fig. 8. IR Spectra of artificial rubber G-7.

The analyses of the spectrum of rubber G-6 reported the presence of several pronounced peaks related to the presence of foreign elements in the rubber structure. Unfortunately, identifying fillers remains problematic because of its peaks' overlap.Consequently, auxiliary analytical methods could be applied to determine the chemical composition.

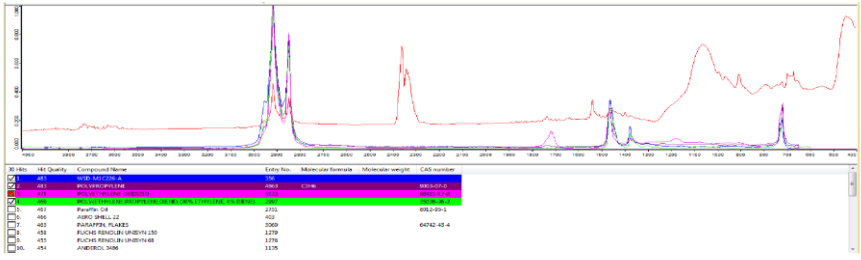

Fig. 9. IR Spectra of artificial rubber G-8.

The presence of several pronounced peaks related to the presence of foreign elements in the rubber structure could be noted by analyzing the spectrum of rubber G-8. Analysis was a means to address the commercial name polyethylene, polypropylene polymer, a chemical mixture consisting mainly of butyl and polysulfide (figure 9).

The presence of rubber as basic material was identified in all the spectra. Groups of curves of spectra in the wavelength range 2850 -3000 cm^{-1} resulting from links absorptions of C-H_3, C-H_2 and C-H during deformation. Curves group with wavelengths 2300 - 2400 cm^{-1} is due to the nitrile group

which seems to be present in all the tested samples. In addition, the peaks frequencies of wave number 1500-1600cm^{-1} presenting the group of carbonile and the weave length 900 - 1000cm^{-1} presenting the group of sulfoxide are present in the tested samples. The different fillers in rubbers might be the source for the small differences in wavelengths of spectra. The greatest impact in fillers is the intensity of peaks, as well as their duplication.

The presence of glass fibers as the main filler could be met during the analyzing and comparing of the spectra library of software Opus.

Figure 10 and 11 depictthe SEM micrograph of rubber G-2. The spectra show the presence of many types of filler in rubber G-2. Fillers and chemical composition could be identified by defining the respective targets via EDS system.

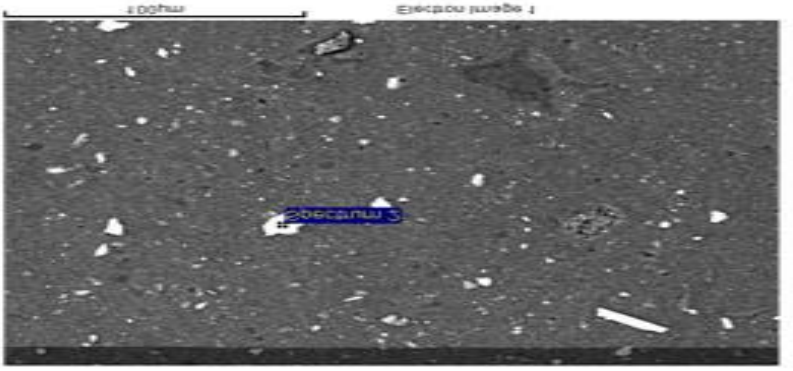

Fig. 10. SEM EDS Spectra for artificial rubber G-2.

EDS spectra for the sample rubber G-2 shows the presence of iron, sulfur, zinc, aluminum and magnesium. Sulfur and zinc are the basic elements in vulcanized rubbers. Other elements are added as fillers mainly in the form of oxides.

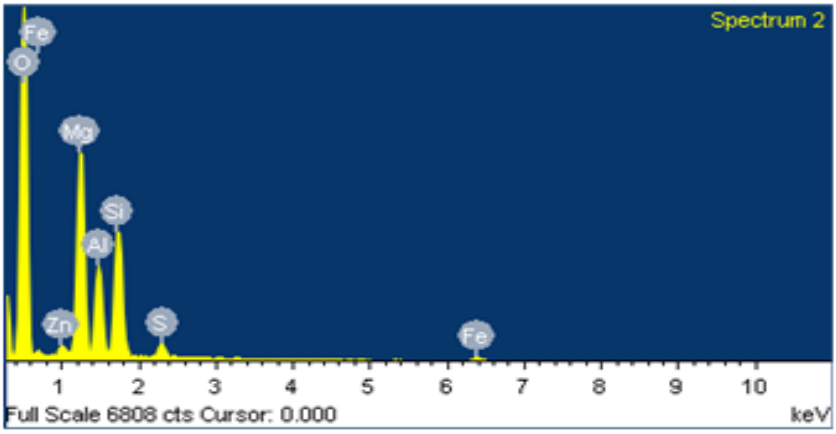

Fig. 11 SEM EDS Spectra for artificial rubber G-2

5. CONCLUSIONSAND DISCUSSION

The present paper aims to investigate the structure and the contentof recycled tires used in artificial turf/ grass as infill materials.Structural investigation involved vibration spectroscopy with infrared Fourier transformation and SEM.

Analyzes ofthe received spectra helpedidentify rubber as a basic element in all thetested samples. In addition, efforts were made to identify the fillers used for strengthening the physical-mechanical propertiesof the rubber. The low intensity of peaks shown in spectra made the identification of fillersdifficult. The sources are the small number of additives and the overlapping of peaks from different chemical compounds. The presence of filler in rubber becomes even clearer using the electronic scanning microscope, equipped with power distribution system for the identification of chemical elements. A micro view with its spectrum in the targeted position is in figure 10 and 11 depicted. The present paper reports about the rubber sample G-2.

The two tested methods in combination with which other allowed identifying all the presented elements in the rubber samples.

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EFFECT OF PARALLELISM IN CALCULATING THE EXECUTION TIME DURING FORECASTING ELECTRICAL LOAD

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ABSTRACT

The electrical load is of great economic importance to electric power industry. Load information is of a great technical importance for a *stable electricity* system as a secure supply could be guaranteed. The present paper aims at finding the effect of parallel computing in terms of execution time of the scripts used for the mathematical models of load profiles to address the forecast of electrical load. A parallel system based on the sequential and parallel execution of the scripts by splitting input data was used to investigate the effect of parallelism. The mathematical pattern was derived from the regression model with several independent variables and represent the dependence of electrical load upon time, temperature and humidity. Regression analysis involved the programming environment R. In addition, the data have been analyzed for a clearer picture of data distribution.
Keywords: load profile, R, parallel processing, electric load and forecast

1. INTRODUCTION

Predicting the electric load is challenging as electricity consumption might be affected. The model used for the prediction is based on factors such as time, temperature, humidity, tariffs, season, etc.The various data mining techniques used make it even more difficult.

As the capacity of load profiles and data is growing, their processing is harder. These data are generally referred to as the big data due to their large capacity velocity and variety. Keka and Çiço (2015) used the Revolution R Enterprise (RRE) tool to process the data and find the relationship between electric power and time, as well as to visualize the smoothing line.

Keka and Çiço (2015) reported about the relationship between the two variables; electric energy and time based on descriptive statistics. Keka and

Çiço (2016) evaluated both the linear relationship and visualization of the load profile data. Parallel computing based on parallel package was reported in (Gordon, 2015), but in this case, setting up the number of workers or number of clusters to do the job was needful. In addition, the caching method to save the result from previous work and to add to the other function to complete the job was used. To reduce the time consuming during calculations in the computers with multiple core processors, (Leach, 2014) proposed the parallel backend, i.e., execution of code across multiple cores.

In this paper, to find the effect of parallelism, the executions of the scripts have been made splitting the data of a period of 4 years in chunks of six months. The Polytechnic University of Tirana (PUT) possesses the parallel system. The Top-Down method was used to read or measure the electric power. The Multiple Linear Regression Method (hereinafter MLR method) was applied for the prediction of the electric load. The following three factors, or independent variables such as time, temperature and humidity were used to get the best fit line model.

2. LITERATURE REVIEW

Many papers about the different tasks and techniques of data mining used in the power electricity systems, have been reviewed as reported in the Table 1 (Keka and Çiço, 2015).

Table 1. Number of tasks and techniques used in the papers

Papers	Tasks	Papers	Techniques
20	Prediction	15	Artificial Neural Network (ANN)
10	Clustering	7	Bayesian technique
6	Classification	8	Decision tree
4	Other	10	Support Vector Machines (SVM), Regression model, K-means, Fuzzy BP

Many papers have used prediction, clustering, or classification as a task. In addition, many of these papers have used the neural network, Bayesian (Mohammad, 2012), regression model, decision tree, etc. to handle the data.

Ryohei and Satoshi (2012) predicted the electrical consumption using mixed collected data. Seetha and Saravanan (2007) used clustering techniques from the past data for the network to reduce forecasting errors. Lalitha (2012) predicted, detected and quantified the exercise of short-term strategic

behaviors in wholesale electricity markets. To the distribution companies is essential to forecast the electricity consumption for residential, industrial, agricultural, or provincial customers (Küçükdeniz, 2010). Ahiakwo (2010) forecasted the electricity demand which is dependent upon the time from one hour up to a week. Seetha (2007) used classification techniques or clustering techniques from the past data for the network to reduce forecasting errors. These papers have used the bottom-up methodology, i.e., the data from the end consumers.

The present paper is based on the on top-down methodology. The data from the substations to the customers were here involved —so far unreported method.

3. MATERIALS AND METHODS

R is a programming language that is used for statistical analysis, visualization, prediction, clustering, classification, and packages. The R has some limitations because it reads and loads the data in the RAM memory of the computer. If the PC have many cores of the CPU, it will use by default only one core.

Parallelism means running several computations at the same time and taking advantage of multiple cores or CPUs on a single system, or CPUs on other systems (Rosario, 2010). For parallel processing are used packages of R like RevoScale R (Rickert, 2010), snow packages, Big memory packages, for each package etc.

In the present paper, the High-Performance Computing (HPC) resources of PUT which consists of three blocks of 8 Blade Servers, interconnected through 1 Gbps Ethernet switches, with 24 nodes based on Dual Intel Xeon E5506 processors 8 cores, with 4 GB RAM and 146 GB HDD per node, running Scientific Linux 6.7 with programming environment based on C and R and MPI was used.

A power system contains several data acquisition equipment such as meter reading to customers for billing, meter reading from substation to calculate the streaming energy, or for calculating the technical losses. In addition, the Supervisory Control and Data Acquisition (SCADA) that collects the data in the case when the relay is open or closed in any substation might be used. The SCADA also collects the data that can be considered as heterogeneous variables such as maximal Power (Pmax), active Energy, and reactive Energy. The data collected from the SCADA could considered as Big Data which are organized in the databases known as Data Warehouse. They are large regarding the volume; they are in different formats and are streaming data.

The data from load profiles of the electric grid in Kosovo are here used. The load profile is a comma-separated values (CSV) file, which contains

various data of electricity such as maximal power, reactive power, on/off switching or disconnecting and other data. In the present paper, we use just maximum power and time from the load profile as in Table 2 reported. These data are obtained from the smart metering of every 15 minutes. Smart meters are installed on the boundary between TSO and distribution parts based on the automatic meter reading (AMR) system. Thus, AMR is used as a source of big data in electricity, because collects, stores and transmits data of electric power, reactive power, load consumption etc., to the central system.

Load profiles contain data population for54substations covering about 500.000 consumers and *quadrennial* measurements. Information about electricity power and measurements is here reported.

Table 2. Load Profile Data

Time	**SS_B A** (kW)	**SS_GJ 1** (kW)	**SS_GJ 2** (kW)	**SS_B R** (kW)	**SS_GJ 1_R** (kW)	**SS_GJ 2_R** (kW)
7/1/2009 0:00	5478	11176	5808	3366	7128	3696
7/1/2009 0:15	5478	11176	5808	3366	7128	3696
7/1/2009 0:30	5082	10384	5368	3432	6688	3608
7/1/2009 0:45	4884	9856	5104	3498	6864	3696
7/1/2009 1:00	4554	9328	4840	3498	6952	3696
7/1/2009 1:15	4290	8888	4576	3498	6952	3696
7/1/2009 1:30	4158	8624	4488	3366	7304	3872

We have also used *quadrennial* data about temperature and humidity which are in a comma-separated values (CSV) format. However, only the columns that contain temperature and relative humidity data were used. Writing the scripts helps to read load profiles and to load it in R.

The script for loading data and generating visualization could be presented as pseudo-code:

```
j<read.table("D:/file.csv",sep=",",dec=",",header=TRUE,stringsAsFactor=FALSE)
        Data<-strptime(j$Data,"%d.%m.%Y %H:%M")
daterange=c(as.POSIXlt(min(j$Data)),as.POSIXlt(max(j$Data)))
         jo<-j[1:96,c("Data","Var1","Var2","Var3")]
        jo.range<-range(0,jo$Var,jo$Var1)
```

```
plot(jo$Data,jo$Var1,type="l",col="",ylim=jo.range, xlab=" ", ylab=" " )
        lines(jo$Data,jo$Var2,col=" ")
        lines(jo$Data,jo$Var3,col=" ")
```

In addition, the execution of the scripts based on the MLR generates the graphs for three cases (Figure 2). The first graph plotsthe best fit line for the correlation between electric power and time.The second graph plotsthe relationship between electric power and temperature. The third graph plotsthe relationship between electric power and relative humidity (dewpoint). In allcases, the fit lines are linear but decreasing.

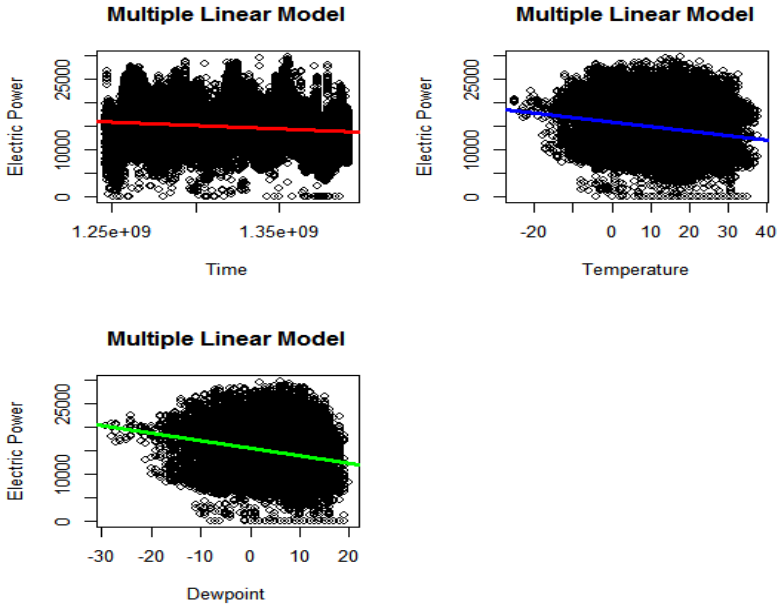


Fig. 2. Best Fit Line for Three Cases

The relationship between power and time, temperature, relative humidity based on the Multiple Regression Line Model is expressed as below:

$$y = f(x) = a_0 + \sum_{n=1}^{\infty}(b_n x_n) + \varepsilon \qquad (1.1)$$

Where a_0 and b_n are the parameters of the equation; the $x_1, x_2, \ldots\ldots\ldots\ldots, x_n$ are the independent variables; y is the dependent variable of the model; ε is the error term of the model.

Based on the equation (1.1) we have got the relationship of Electric Load and three independent variables, time, temperature and relative humidity. We can see that the intercept is positive $4.113e^{+04}$.

$$Power = 4.113e^{+04} - 1.934e^{-05} * time + 9.107e^{+00} * temperature - 1.863e^{+02} * devpoint \quad (1.2)$$

The equation (1.2) is gained to minimize the Least Square Regression (LSR) Error which is expressed based on equation (1.3):

$$\varepsilon_i = Y_i - \ddot{Y}_t$$
$$\sum_{i=1}^{n} \varepsilon_i{}^2 = \sum_{i=1}^{n} [Y_i - \ddot{Y}_t]^2$$
$$Y_i = c + b_1 x_1 + \cdots + b_i x_i \quad (1.3)$$

Where Ÿ is the predicted values and ε_i presents difference between observed and predicted values.

4. RESULTS OF PARALLELISM

We have tested three cases about the execution time of the scripts. The first case is when we execute the script that includes data about four years, from 2010-2014. The time unit of the script execution for all tables is expressed in second (s).

Table 3. Execution time in Parallel System

	Time in Parallel System (s) With 1 factor			Time in Parallel System (s) With 3 factors		
	user	system	elapsed	user	system	elapsed
MLR_bestfitline	3.72	0.48	4.28	6.09	0.11	6.21
MLR_L6m 2009	0.44	0.09	0.53	0.79	0.01	0.80
MLR_F6m 2010	0.41	0.09	0.50	0.77	0.01	0.78
MLR_L6m 2010	0.44	0.09	0.53	0.76	0.01	0.78
MLR_F6m 2011	0.41	0.09	0.51	0.73	0.02	0.75
MLR_L6m 2011	0.45	0.09	0.54	0.75	0.02	0.77
MLR_F6m 2012	0.43	0.08	0.51	0.76	0.01	0.77
MLR_L6m 2012	0.44	0.09	0.53	0.78	0.02	0.80
MLR_F6m 2013	0.40	0.08	0.50	0.75	0.01	0.76
MLR_L6m 2013	0.44	0.08	0.53	0.76	0.02	0.8
Average	0.43	0.09	0.52	0.76	0.01	0.78

The Table 3 reports the model quadrennial data and the execution time in parallel system with one factor and three factors. So, user runtime for the whole period was 3.72 seconds with one factor and 6.09 seconds with three factors. To run the model in parallel, the data was divided into chunks of 6 months. The runtime for each of 6 months data chunks isin Table 3 reported: theuser runtime is less in the case of user time with one factor than comparing with three factors.

In addition to the system time and elapsed execution time reportedin the table, the averages of runtime for 6 months data chunks were calculated. Based on these data the user runtime (in second) was evaluated based on these data and the results arein the Table 4reported.

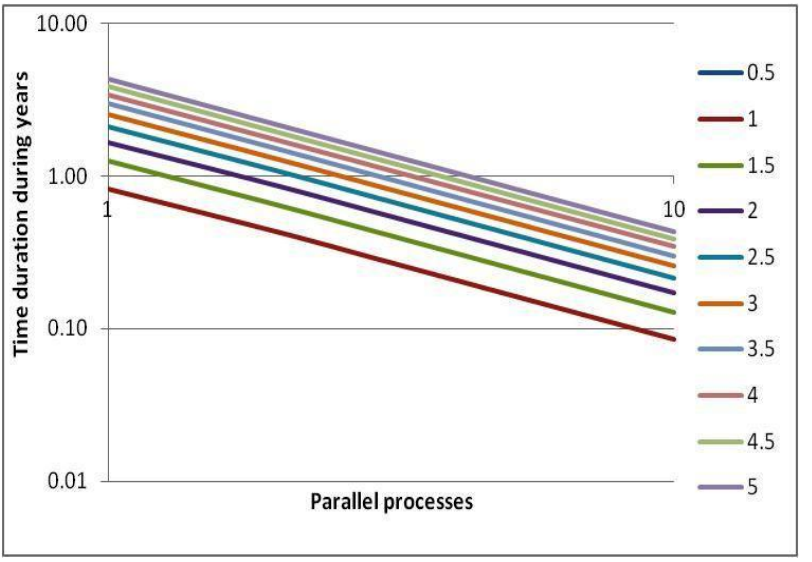
Table 4. Time duration in years based on parallel processes with 3 factors

		Parallel processes									
		1	2	3	4	5	6	7	8	9	10
Time duration in years	0.5	0.77	0.76	0.51	0.38	0.30	0.25	0.22	0.19	0.17	0.15
	1	1.50	1.14	0.76	0.57	0.46	0.38	0.33	0.29	0.25	0.23
	1.5	2.26	1.52	1.02	0.76	0.61	0.51	0.44	0.38	0.34	0.30
	2	3.01	1.90	1.27	0.95	0.76	0.63	0.54	0.48	0.42	0.38
	2.5	3.80	2.28	1.52	1.14	0.91	0.76	0.65	0.57	0.51	0.46
	3	4.56	2.66	1.78	1.33	1.07	0.89	0.76	0.67	0.59	0.53
	3.5	5.31	3.05	2.03	1.52	1.22	1.02	0.87	0.76	0.68	0.61
	4	6.09	3.43	2.28	1.71	1.37	1.14	0.98	0.86	0.76	0.69
	4.5	6.85	3.81	2.54	1.90	1.52	1.27	1.09	0.95	0.85	0.76

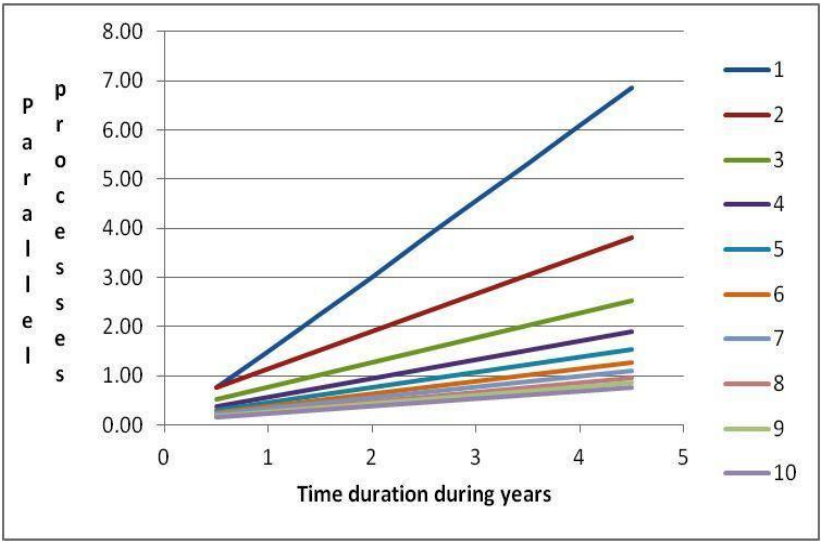
The Table 4 reports thechanges of the user runtime when the parallelism growsand the amount of data increases. The graph 1plots the decrease of the execution time when the numbers of processes are increased and when we have only one factor: time. The graph2 plots the increase of execution time depending on the amount of the data increased during the years and when we have three factors.

First case of parallelism calculation is one when in the relationship (model) we have one factor: time. The second case of parallelism calculation is one when in the relationship (model) we have three factors, or independent

variables such astime, temperature and humidity, which affect in the dependent variable.



Graph. 1. The Effect of Parallelism with 1 factor

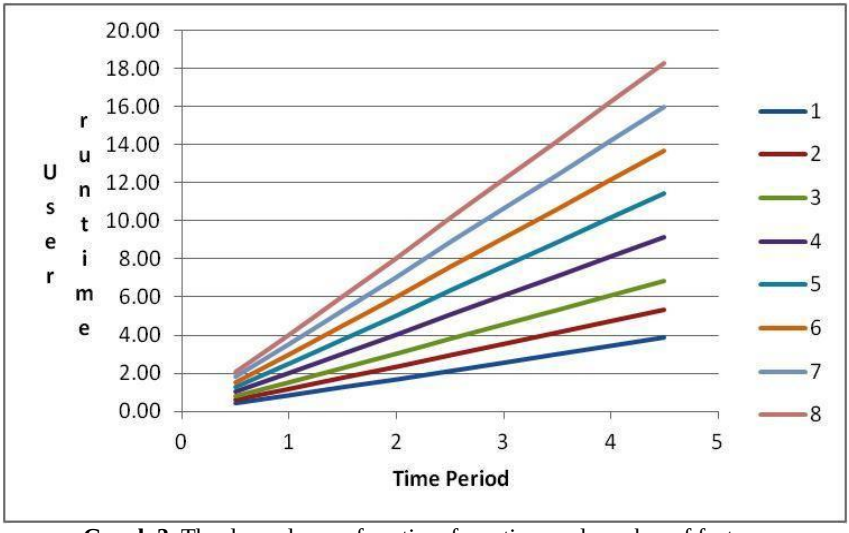


Graph.2. The Effect of Parallelism with 3 factors

The Table 5reports the evaluation of variation of user runtime in years (increasing amount of data) for different number of factors. This dependence is in the graph3plotted.

Table 5. User runtime during time periods

	Time Periods								
		1	2	3	4	5	6	7	8
User runtime	0.5	0.41	0.59	0.77	1.03	1.28	1.54	1.80	2.05
	1	0.82	1.16	1.50	2.00	2.51	3.01	3.51	4.01
	1.5	1.25	1.76	2.26	3.01	3.77	4.52	5.27	6.02
	2	1.65	2.33	3.01	4.01	5.02	6.02	7.02	8.02
	2.5	2.09	2.95	3.80	5.06	6.33	7.60	8.86	10.13
	3	2.53	3.55	4.56	6.08	7.60	9.12	10.64	12.16
	3.5	2.98	4.15	5.31	7.08	8.85	10.62	12.39	14.17
	4	3.42	4.76	6.09	8.12	10.15	12.18	14.21	16.24
	4.5	3.86	5.36	6.85	9.14	11.42	13.70	15.99	18.27



Graph.3. The dependence of runtime from time and number of factors

5. CONCLUSIONS

The relationship between electric power and the three independent variables such astime, temperature and relative humidity was based on the data of load profiles. This relationship wasfound applying the MLR which involved the software Rto minimize the error term. The parallelization by splitting the input data in chunks gave the maximal scalability, making possible the evaluation of runtime in different similar scenarios. Runtime increases linearly with the volume of input data for the used parallelization method. For multi-factor models, the runtime increases about 40% per new factor. Other parallelization techniques within R increasing the volume of input data and the number of factors would be recommendable to further such investigation.

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THE IMPLEMENTATION OF PROGRESSIVE TAX IN ALBANIA

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ABSTRACT

Taxation is a means by which governments finance their expenditure by imposing charges on citizens and businesses as one of the financial resources provided to the state and has an impact on the distribution of income. The present paper gives a report on taxation, and application of both progressive and flat taxation. Given the benefits of an appropriate taxation and the current situation in Albania, the implementation of right taxation law and its procedures would be of great importance for the society. The information provided here is addressed to policymaking bodies. Taxation must be based on economic characteristics of the country, the citizens' incomes and their behavior towards the different fiscal regimes.
Keywords: taxation, progressive, flat, VAT, fiscal culture, tax receipt, level, model

1. INTRODUCTION

Taxation is a means by which governments finance their expenditure by imposing charges on citizens and corporate entities as one of the financial resources provided to the state and has an impact on the distribution of income.

Citizen is a person who is entitled to enjoy all the legal rights and privileges granted by a state to the people comprising its constituency and are obligated to obey to its laws to fulfill his duties as called upon.

Business is a means to address economic development of a country due to investments and employment opportunities. Businesses are called to pay taxes such as VAT and CIT (Corp. Inc. Tax).

State refers to a nation or territory considered as an organized political community under one government. Every government has its own bodies that are authorized by law to perform any executive, legislative, judicial, regulatory, administrative, military, or police functions of the government, guaranteeing effective use of labor, land, capital, entrepreneurial ability,

exploitation of innovative ideas about technology, in function of sustainable economic growth and social stability.

Sandel (2017) stated that John Locke believed that governments cannot be supported without great charge, and it is fit everyone who enjoys his share of the protection, should pay out of his estate his proportion for the maintenance of it. But still it must be with his own consent, i.e. the consent of the majority, giving it either by themselves, or their representatives chosen by them.

Taxation is not an invention of our times; its origins lie in the ancient civilizations, when Greeks and Romans levied taxes on their citizens to pay for military expenses and other public services. It evolved significantly as empires expanded and became more structured.

Today, taxation is sanctioned by law and includes expenditures on economic infrastructure (roads, public transportation, sanitation, legal systems, public safety, education, health-care systems), military, scientific research, culture and the arts, public works, distribution, data collection and dissemination, public insurance, and the operation of government itself. A government's ability to raise taxes is called fiscal capacity.

Montesquieu (2000) said that governments encourage the free market, i.e., freedom of economic enterprise and the freedom is the right to make whatever laws allow.

The Albanian legislation (law no. 9920 dt. 19.05.2008) "On tax procedures, in the Republic of Albania" - amended, Article 12, the "Principles of tax administration", imposes self-assessment and self-declaration of tax, by the taxpayer and encourages the voluntary observance of the fiscal legislation.

But is this legal basis respected "*de facto*" by citizens and businesses, and do the tax administration bodies manage effectively its implementation?

1.1. *The current scheme: Personal income tax (PIT), CIT and SCIT, VAT*

Table 1 reports on tax rates based on personal income and annual turnover as predicted by the law.

Table 1 Tax rates based on personal income and annual turnover

Current coefficients	Segment / ALL		Tax rate
Personal income tax(PIT)	0	30,000	0%
	30,001	130,000	13%, for the amount over 30,000 ALL.
	130,001	+	23% for the amount over 130,000 ALL
Simple corporate income tax (SCIT)	0	5,000,000	0% (for small business)
	5,000,001	8,000,000	5% (for medium business)
Corporate income tax (CIT)	8,000,001	+	15% (for big business)

Taxable supply for VAT	0	5,000,000	0%
	8,000,001	+	20%
So, according to annual business turnover	0-5,000,000	5,000,001-8,000,000	> 8,000,000
Simple corporate income tax (SCIT)	0%	5%	No
Corporate income tax (CIT)	No	No	15%
Value added tax (VAT)	No	20%	20%

2. MATERIALS AND METHODS

Cormick (1974) said that John Stuart Mill (1806-1873), one of the most influential English-speaking philosophers of the nineteenth century, believed that the greater a taxpayer's ability to pay, the less the sacrifice he suffers from paying a given amount of tax.

2.1. *Advantages and disadvantages between the flat tax versus progressive tax*

Table 2 reports about the advantages and disadvantages of the two types of taxes (Bela, 2013).

Table 2 Advantages/disadvantages between flat tax and progressive tax.

FLAT TAXATION	
Advantages	**Disadvantages**
Business incentives through lower taxes	Low incentive for small businesses
Incentives for citizens and businesses with higher incomes	Small savings for citizens and businesses with low income
It is easily managed when the administration is not qualified	Trends for negligence and ineligibility
Attract foreign investors	Can avoid serious investors
Easy to understand	Problems with image
PROGRESSIVE TAXATION	
Advantages	Disadvantages
Stimulates savings by households	Stimulation is smaller for large businesses
Creates a positive image	It encourages foreign investors doubt
Stimulates trainings for tax administration	Increases costs of administration
It attracts serious foreign investors	Averts other potential investors
Increases investment	It tends to encourage tax evasion

2.2. *Current challenges in Albania*

The non-declaration of transactions remains problematic, regardless the efforts made to fight informality. The 5 million ALL threshold for annual turnover which is not taxed encourages the non-issuance of the tax receipt,

when is widely known that it is the last “link” in the “chain” to final declaration, of the transaction.

If one purchases at the groceries in the evening and gets the tax receipt, the tax receipt number would be 20, which means that only 20 customers purchased so far—unlikely—as 250-300 transactions per day could be made under normal conditions.

Exemplifying, each grocery covers 80 families (4 palaces x 20 families/palace). Each family spends monthly 20,000 ALL. With normal issuance of tax receipt, from fiscal cash register, the effect would be 16,667 ALL—a trader’s income— of which 3,333 ALL would go to the national treasury. Table 3 reports the effect of abuse.

Table 3 VAT Abuse

LOSS OF VAT, FROM FAILURE TO ISSUE TAX RECEIPT	Citizens expenses	Net value	Undeclared VAT [ALL]
Monthly consumption per family	20,000	16,667	3,333
No. of families in 4 palaces	80		
Expenses for 80 families /Monthly turnover undeclared by a store	1,600,000	1,333,333	266,667
Annual expenditure of 4 palaces/The annual turnover undeclared by 1store	9,200,000	16,000,000	3,200,000

Tax evasion is the illegal evasion of taxes by individuals, corporations, and trusts. Tax evasion often entails taxpayers deliberately misrepresenting the true state of their affairs to the tax authorities to reduce their tax liability and includes dishonest tax reporting, such as declaring less income, profits or gains than the amounts earned, or overstating deductions.

Tax evasion is an activity commonly associated with the informal economy. One measure of the extent of tax evasion (the "tax gap") is the amount of unreported income, which is the difference between the amount of income that should be reported to the tax authorities and the actual amount. If a dealer receives 20,000 ALL, 3,333 ALL belong the state's budget. Taxation is sanctioned by law and includes expenditures on economic infrastructure (roads, public transportation, sanitation, legal systems, public safety, education, health-care systems), military, scientific research, culture and the arts, public works, distribution, data collection and dissemination, public insurance, and the operation of government itself. Unfortunately, the amount of incomes received are misused and not properly declared by the dealer. Consequently, taxes are not paid. As the table reports, the tax evasion is estimated **3,200,000 ALL** (Bela, 2014). Taxes non-declaration or improper tax declaration is the source of abuse from importers/large-scale producers to retailers.

2.3. *Suggestions for application of progressive tax, for wages, in Albania*

2.3.1. Nontaxable level

Bela (2013) emphasized that the level of incomes that meet the demand for nutrition, should not be subject to any personal income tax, or a tax rate equal to 0% ought to be applied and the rest could be used for taxes.

The Swiss Society for Nutrition (Ernährung 2012; 2017) recommended healthy eating pyramid which contains the core food groups, according to how much they contribute to a balanced diet based. In addition to the Swiss Society for Nutrition, the food diet suggested by Nikollska and Slabejkoska (2014) from the Ministry of Education and Science of the Republic of Macedonia was here involved to investigate the current situation of VAT. Current data on market prices were obtained from the official sites of Albanian supermarkets. We also used figures from Numbeo (2017) which provided timely information about worldwide living conditions including Albania. The database from the Institute of Statistics was used for an accurate evaluation of the non-taxable level.

Data about the monthly expenditure, estimation of household monthly calories, population number, number of Albanian families, the total number of employees at the national level, the average number of family members employed, the grocery budget of an average Albanian family, distribution of this amount to number of employed per families, approximation of this value as the basis for (Personal Income Taxes) PIT=0% are important for the estimation of costs for a healthy nutrition.

Alternative I:

Table 4 reports about the monthly expenses for the Swiss diet.

Table 4. The monthly expenses for the Swiss diet

No	**Nutrition diet for normal person based on the Swiss Society for Nutrition**				**Prices according towww.numbeo.com and current market prices (06.02.2017)**			
	Recommendation	Average	Unit	Convertor	Base unit	Price/ Unit	Daily value	Monthly amount
		Daily		[kg, lit]		ALL	ALL	ALL
1	Drinks:							
	1-2 liters of water and /or tea-coffee	1.50	lit	1.50	Liter	36.90	55.35	1,66
2	**Vegetables and fruits (five a day intake)**							
	3 servings of vegetables, 120	360.00	gr	0.36	Kg	71.50	25.74	772

	gr each							
	2 servings of fruit, 120 gr each	240.00	gr	0.24	Kg	124.00	29.76	893
3	**Grain products, legumes, potatoes**							
	75 - 125 gr bread / pasta / pizza	100.00	gr	0.10	Kg	130.00	13.00	390
	60 - 100 gr beans, chick peas, lentils	80.00	gr	0.08	Kg	250.00	20.00	600
	180 - 300 gr potato	240.00	gr	0.24	Kg	60.55	14.53	436
	45 - 75 gr rice	60.00	gr	0.06	Kg	130.56	7.83	235
4	Dairy product, meat, fish and eggs:							
	200 ml. milk	200.00	ml	0.20	Liter	120.90	24.18	725
	30-60 gr chees	60.00	gr	0.06	Kg	502.86	30.17	905
	100 - 120 gr meat /fish	110.00	gr	0.11	Kg	700.00	77.00	2,310
	150 -180 gr yogurt	165.00	gr	0.17	Liter	120.90	19.95	598
	2 - 3 eggs	2.50	eggs	2.50	Eggs	12.71	31.78	953
5	**Oils and dried fruits (walnuts, hazelnuts, peanuts, almonds, etc.)**							
	2-3 teaspoons of olive oil for salad /10-15 gr	12.50	gr	0.01	Kg	700.00	8.75	263
	2-3 teaspoons of olive oil for cooking /10-15 gr	12.50	gr	0.01	Kg	700.00	8.75	263
	20 -30 gralmonds / walnuts / hazelnuts	25.00	gr	0.03	Kg	600.00	15.00	450
6	Sweets, salted or fresh drinks							
	Eat carefully	1.00	unit	1.00	unit	100.00	100.00	3,000
TOTAL AMOUNT (daily and monthly for a normal person) / ALL							**482**	**14,454**

Monthly expenses go up 14,782 ALL. Reallocation of values was necessary for an accurate assessment of incomes level which should not be taxed (Table 4).

Table 5 Alt. I for PIT=0%

Family members, and calories by age (cnpp.usda.gov)		**Distribution in proportion to calories / in ALL**	**Monthly expenses for two young people and two adults**
Boy 18 years old	2,800	14,454	47,491ALL
Girl 18 years old	2,000	10,324	
Man 46-50 years old	2,400	12,389	

Women 46-50 years old	2,000	10,324	
Population / 31.12.2015 (INSTAT, 2016)			2,886,026
No. of families by 2011 Census(INSTAT, 2012)			726,895
Average no. of family members = Population / no. of families			4
Total employed / 2015 (INSTAT, 2016, numbers)			973,000
Average employed per families = employed / no. families			1.34
Part to be covered by employees / in ALL			47,491
Distribution for 1.35 employed for family			35,178
PIT suggestion = 0%,for incomes (rounded) to:			**40,000ALL**

Results reported that the level of salary which must be taxed at 0% rate for personal income from employment should be from 0 to 40,000 ALL.

Alternative II:

Table 6 reports on the Macedonian eating pyramid (Nikollska and Slabejkoska 2014)

Table 6. Monthly expenses based on Macedonian diet

Type of meal	Type of food	Daily average	Unit	Converted amount	Unit	Price	Value in ALL
Breakfast	Milk or yogurt	200	ml	0.2	Liter	120.90	24
	Carbohydrate/honey	40	gr	0.04	Kg	600.00	24
	Bread, pasta	100	gr	0.1	Kg	130.00	13
	Eggs	2	eggs	2	Eggs	12.71	25
	Cheese, butter	45	gr	0.045	Kg	502.86	23
Snacks	Fruit, fruit yogurt	200	gr	0.2	Kg	124.00	25
Lunch	Soup	200	ml	1	Plate	150.00	150
	Meat/chicken, fish	150	gr	0.15	Kg	700.00	105
	*cooking oil/olive oil	30	ml	0.03	Liter	700.00	21
	Bread	100	gr	0.1	Kg	120.00	12
	Vegetable	200	gr	0.2	Kg	71.50	14
	Green salad	100	gr	0.1	Kg	71.50	7
	Fruit or dessert	100	gr	0.1	Kg	124.00	12
Snacks	Fruits, juices	200	gr	0.2	Kg	124.00	25
Dinner	Different spaghetti	200	gr	0.2	Kg	70.00	14
	Bacon	50	gr	0.05	Kg	65.00	3
	Yogurt	200	ml	0.2	Liter	120.90	24
	Fruit	150	gr	0.15	Kg	124.00	19
*Water/added	Water	1500	ml	1.5	Liter	36.90	55
The daily value							596
Monthly amount							**17,882**

Table 7 reports on reallocation of values for a more accurate estimation of nontaxable incomes.

Table7Alt. II for PIT=0%

Family members, and calories by age (cnpp.usda.gov)		**Distribution in proportion to calories / in ALL**	**Monthly expenses for two young peopleand two adults[ALL]**
Boy 18 years old	2,800	17,882	58,754
Girl 18 years old	2,000	12,773	
Man 46-50 years old	2,400	15,327	
Women 46-50 years old	2,000	12,773	
Population / 31.12.2015			2,886,026
No. of families (Census 2011)			726,895
Average no. of family members = Population / no. of families			4
Total employed / 2015			973,000
Average employed per families = employed / no. families			1.34
Part to be covered by employees / in ALL			58,754
Distribution for 1.35 employed for family			43,521
PIT suggestion = 0%, for incomes (rounded) to:			**40,000**

Results from the second alternative, reported that the interval from 0 ALL to 40,000 ALL should be nontaxable.

In both cases, 40,000 ALL is the base amount which must be taxed at 0% rate, for personal income from wages.

2.3.2. *Taxable level over 40,000 ALL*

Unfortunately, both non-declaration and improper declaration of taxes occur. Non-exceedance of the maximum rates provided for business profits would be advisable.

2.4. ***Application of the flat tax on profits of businesses, stimulation of citizen, review of VAT***

2.4.1. *Resistance to fiscal culture and its effects in years*

Memushi (2004) said that culture includes the ideas, customs, and social behavior of a particular people or society. Society is a large group of people who live together in an organized way, making decisions about how to do things and sharing the work that needs to be done.

Unfortunately, misconduct from businessmen and individuals towards laws and rules could be reported everywhere, even in Albania. The phenomenon of uninsured employees or workers characterize the nowadays society.

October 2015 marked 118 thousand workers registered, in comparison with October 2014 (DPT, 2015).

The source for abuse is undeserved employment in addition to workers or employees' uninsurance and misuse of key positions.

Given the current situation, reducing fiscal evasion would be crucial.

2.4.2 Alternative solutions toreducing of VAT's threshold

Taxation has gradually evolved since the ancient times. Today, it is a means by which governments finance their expenditure by imposing charges on citizens and businesses as one of the financial resources provided to the state and has an impact on the distribution of income. The implementation of a right fiscal regime would be of great importance for the society. Here, encouraging the society to prevent economy from failure would be of immediate importance.

Preventing economy from failure

Given the current economic situation in the country, appropriate social-economic schemes would be crucial.

Financial rewards (water and electricity, telephone bill'sreimbursement) receipts (Kosovë, 2017) would encourage tax compliance.

Trade relations among nations are very important as agreements where the fiscal procedures are foreseen could be signed. In addition, appropriate education policies would be of irreplaceable importance (Bela, 2014).

The table 8 reports about the encouragement of fiscal transparency.

Table 8. Financial reward

The minimum number of tax receipts, in three months	**Group I: 50**		**Group II: 80**		**Group III: 100**	
Segments of values, for three months, in ALL	30,000	50,000	50,001	80,000	+ 80,000	
The value of refunds / fixed in ALL	1,500		3,000		4,000	
% e refund	5%	3%	6%	3.75%	5%	<5 %
The average value for receipt / in ALL (ALL)	600	1,000	625	1,000	800	...

In the table 3 possibilities are discussed: i) tax receipts with a total value varying from 30,000 to 50,000 ALL. If the minimal number of tax receipts for three months is 50, the reimbursed could be 1,500 ALL, ii) tax receipts with a value varying from 50,001 to 80,000 ALL. If the minimal number of tax receipts for three months is 80, there imbursed could be 3,000 ALL and, iii) tax receipts with values more than 80,000 ALL. If the minimal number of tax receipts for three months is 100, there imbursement could be 4,000ALL.

As the model offers a minimum number of tax receipts, abuses are avoidable.

The high level of financial reward in the second group encourages tax compliance. The maximum level in the third group prevents businesses from abuses with tax receipts of great values. Quarterly financial reward, allows more coherent and correct verification, by tax administration bodies.

In addition, the value of tax receipts should not exceed the value of the declared income from wages as abuses would be reduced. Financial rewards from tax receipts encourage labor market. Also, the pension situation could be immediately improved.

The decrease of VAT threshold, from 5 to 2 ml ALL

Given the current situation, the differential threshold of VAT is damaging to fair competition, and encourages fiscal abuses to maintain this threshold as here exemplified: subject B (registered for VAT and CIT) and C (unregistered for VAT, CIT or SCIT), buy refreshments in the entity A. The price in both cases is 120 ALL (VAT included) (table 9).

Table 9. Effect of VAT differentiation

	I		
A. Wholesaler registered for VAT and CIT	The taxable value	VAT +	The final sales price for B and C
	100	20	120
	II		
B. Retailer, registered for VAT and CIT	The taxable value on purchase, B from A	VAT -	The final price of the purchase from A
	100	20	120
	The value of taxable sales, of B for client (citizen)	VAT +	The final sale price for the customer
	150	30	180
		10	VAT payable from B, for the state (30-20)
	50		Profit of B (150-100)
	7.5		Profit tax of B, to be paid (50 * 15%)
	17.5 ALL		**Total, for state budget, from B (10 + 7.5)**
42.5 ALL			**Net profit of B (50-7.5)**
	III		
C. Retailer, unregistered for VAT and CIT or SCIT	The taxable value on purchase, C from A	VAT -	The final price of the purchase from A
	No VAT: Exempt purchases from VAT, for C by A		120
	The value of taxable sales, of C for client (citizen)	VAT +	The final sale price for the customer

	No VAT: Exempt sales from VAT, by C, for client		180
	No VAT payable from C, for the state	0	
	Profit of C (180-120)		60
	No Profit tax of C, to be paid		0
	Total, for state budget, from C	**0 ALL**	
Net profit of (60-0)		**60 ALL**	
IV			
C competes unfairly against B		**60 – 42.5 = 17.5 ALL**	

Under the current scheme of VAT (if the threshold of VAT and income taxes from 0 ALL to 5 ml ALL), fair competition is improbable. Lack of fair competition is harmful for the economy. In the present case, C competes unfairly B by subtracting the selling price to the selling price to 162.5 **ALL (180-17.5)**.So, the state budget collects taxes partly.

As taxes are improperly collected, the following alternatives could be suggested: i) elimination of VAT, ii) no threshold for VAT and, iii) decrease threshold for VAT, from 5 to 2 million ALL, to allow fair competition due to chain value.

If the estimated turnover for VAT effect is 2 million ALL, the threshold could be achieved and VAT registration could occur, leading to a fairer competition.

The possibility for legal changes - the application of the flat tax

The application of VAT and progressive taxes in Albania has not been proved successful as most often businesses make dishonest tax reporting, such as declaring less income, profits or gains than the amounts actually earned, or overstating deductions.

If the turnover goes up to 5 million ALL, the businesses close their own Taxpayer Identification Number (TIN) and open a new one until turnover goes up to 5 million ALL again. In addition, businesses with different addresses apply different TIN.

Effect

Tax evasion occurs either by the businesses not included in the VAT, CIT or SCIT or by dishonest tax reporting, such as declaring less income, profits or gains than the amounts actually earned, or overstating deductions. As in both cases the damage caused to the economy is enormous, amendments to the legislation and implementation of a fixed rate tax in the segment, from 9 to15 percent on profit (eliminating the current rates of 0%, 5% and 15%) are advisable.

If tax receipt is provided, the effect on taxable incomes remains the same (businesses have their own CIT) and tax evasion becomes avoidable.

Financial report of the business electronically provided is analyzed by the institutions involved in the area.

Rewards using the tax receipts would be very effective. At the same time, the number of books of purchases and sales must be electronically stated, regardless of turnover level and the businesses committing fiscal evasion must be identified.

In the economy there is a chain effect that occurs due to: i) the flat tax on profits for all businesses, elimination or decrease of VAT threshold, stimulation to take tax receipt for citizens, due to the benefits from the refunds, imposes declaration in real time and real amount, also with real prices of goods and services, from third-level businesses (retailers), ii) the final declarations of sales, by third-level businesses to citizens, imposes the correct declarations of purchases, to justify the birth of incomes, iii) declarations of purchases, from third-level businesses, imposes declaration of sales by second-level businesses (wholesalers), iv) second-level business must declare their purchases to justify their declarations of sales and, v) declaration of purchases by second-level businesses (wholesalers), leads to appropriate declaration from first-level businesses, being importers or manufacturers, and simultaneously defines the appropriate report of imported and exported goods at customs.

Therefore, guarantees the maintenance of the value chain, from initial production or import, to the final consumer.

3. DISCUSSIONS AND RESULTS

There are advantages and disadvantages between the progressive and flat tax. Fraudulent behavior towards declaration of taxes exists throughout the world. The present paper aims at providing adequate solution to the phenomenon.

Given the current socio-economic situation in the country, the incomes spent on food ought to be taxed with 0%. In addition, there is discrimination between the tax rates from the personal income and tax profit. Unfortunately, VAT is not well-managed and taxes are not properly collected.

The present paper reports about the differentiation for tax on profit at three thresholds: 0, 5 and 15 % and the effect it has on the economy. Consequently, the suggestions are made as reported in the table 10.

Table 10. Results of treatment

SUGGESTIONS	SEGMENT / ALL		TAX RATE
i) Income tax, for individuals (PIT)	-	40,000	0%
	40,001	+	15% for incomes over 40,000 ALL
ii) Profit tax, for businesses (CIT)	0	+	15%
iii) Taxable supplies, for VAT	0	2,000,000	0%
	2,000,001	+	20%
or, final alternative => No threshold for VAT, Or No VAT			

ENCOURAGINGPROCEDURES

The minimum number of tax receipts, in three months	Group I: 50		Group II: 80		Group III: 100	
Segments of values, for three months, in ALL	30,000	50,000	50,001	80,000	+ 80,000	
The value of refunds / fixed in ALL	1,500		3,000		4,000	
Refund %	5%	3%	6%	3.75%	5%	<5%
The average value for receipt / in ALL (ALL)	600	1,000	625	1,000	800	...

These procedures would prevent economy from failure because each citizen becomes a direct shareholder in the national economy and transparency of customs procedures, appropriate declaration of incomes, prices and employees, health insurance, VAT throughout the chain value become unavoidable. In addition, fair competition would be guaranteed.

4. CONCLUSIONS AND RECOMMENDATIONS

There are advantages and disadvantages between the progressive and flat tax. Fraudulent behavior towards declaration of taxes exist throughout the world. The present paper aims at providing adequate solution to the phenomenon.

Given the current socio-economic situation in the country, the incomes spent on nutrition ought to be taxed with 0%. The value of 40.000 ALL is the base amount which must be taxed at 0% rate.

In our country, the subsequent steps after the base with tax rate = 0%, should not exceed the maximum rates provided for profits, generated by the business.

There are many steps to be followed to encourage economy transparency. Rewards from tax receipts, elimination of VAT, elimination of threshold for VAT or decrease the threshold for VAT, from 5 to 2 million ALL could be a solution, in addition to the application of a fixed rate in the segment, from 9 to15 percent on profit. Economy transparency is the source for socio-economic development.

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ELECTRIC VEHICLES, CHANCES OF AN EXPANDING MARKET-THE CASE OF ALBANIA

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ABSTRACT

Electric vehicles have recently emerged as an alternative to cheaper, more comfortable and more environmentally friendly means of transportation. Given the importance of such vehicles and the current situation in Albania, opening the Albanian market to this global innovation would be of great benefit. To find out the potential of Electric Vehicles (EVs) in the Albanian vehicle market, the author has referred to the comparative data of both the markets and the vehicles themselves, according to the parameters of the producers. A prime example of the domestic market of such vehicles is the equipment of the state police with aproximately 11 electric vehicles, Volswagen golf model, a fact which reveals not only the benefits but also the barriers to their marketing.
Keywords: electric vehicles, market, environmental friendly, benefits

1. Electric Vehicles' Markets (EVM).

In 1884, Thomas Parker was the first engineer to build the first electric engine, using rechargeable batteries, eligible for production. In 1900, only 22 per cent of cars were fueled while 40 per cent of them were powered by electric motors. But, a better functioning and the far cheaper prices favored the fuel cars that dominate the market until today when an electric car costs twice as much as fuel cars. In the 1930s, fuel vehicles thoroughly dominated the market, but in the 1950-s the damage caused on the environment drove the attention to the electric cars, marking an increasing interest in the 1980s - 1990s. After 2000, large manufacturers started competing in the production of electric car models. Today, this market has expanded to a large extent. Certain countries predict that in a few years they will shift their markets to electric cars. Byers are searching for the most efficient ways to move on the road and

of course the least harmful ones to their health. Companies such as Tesla have done a great job in providing very luxurious and functional electric cars to the public. Other companies, such as Volkswagen with the Golf-models, Nissan Leaf, and Chevrolet Volt, have followed the Tesla model.

1.1. The World market of EVs.

According to a report published by the International Energy Agency (2017), the number of electric cars on the road in 2016 exceeded 2 million. With over 750,000 new orders, 2016 marked a record for electric car sales. Basing on the same report, by 2020, the number of electric cars in circulation will reach 20 million, increasing to 70 million by 2025. Expressed in percentage, two million electric cars make only 0.2% of the cars in circulation and according to optimistic forecasts in 2025 they will make just 7 percent. Table 1 reports the the increasing trend of electric car sales.

Table 1. The trend of electric car in the recent years

Country	**Registrations of EV/PHEV First quarter 2015**	**Quote on total registrations**	**Registrations of EV/PHEV First quarter 2014**	**Quota on total registration**
Norway	8,111	33.1%	5,775	15.8%
Netherlands	5,760	5.7%	3,306	3.1%
United Kingdom	8,684	1.2%	1,764	0.3%
USA	14,832	0.8%	14,799	0.8%
France	3,626	0.8%	1,801	0.4%
Germany	4,520	0.6%	2,286	0.3%
Japan	7,750	0.6%	9,626	0.3%
China	12,555	0.6%	1,486	0.0%
Italy	585	0.1%	236	0.1%

Source: insideevs.com + UNRAE

Many countries have advanced enormously in expanding their markets. Norway is the country where the sale of electric cars has flourished vigorously. About 70,000 such vehicles ride on Norwegian roads. No other country regarding the number of the population – uses as many electric vehicles as Norway does. In Germany too, politics has already decided to promote the purchase of electric cars, through state support with financial rewards. But Norway is ahead as it spends up to 420 million euros a year as financial support for the purchase of electric cars, even though there is no

national automotive industry there. To support this trend, the Norwegian and Dutch legislation predicts the end of vehicles with internal combustion engines in the country by 2020 and 2025, respectively. Currently, China is the world leader in electric car sales. Geely is the Chinese manufacturer that manufactures cars for the US as well, while the world's largest electric car maker, Tesla has tripled its revenue by earning over $ 1 billion in the Chinese market in 2016. The Chinese government has proposed that by 2018, 8 percent of the total fleet should consist of fuel-efficient vehicles, making China very interesting to the electric vehicle market. Meanwhile another big market like India, where air pollution causes 1.2 million deaths a year, plans that by 2030, any car sold in India be electric. It has been estimated that this revolutionary change will save the country from a cost of up to $ 60 billion. While many countries make plans to expand, Japan comes with a different impressive record. According to Nissan, there were more electric vehicle charging stations than gas stations in Japan at the end of 2016. The Japanese car manufacturer reported that the number of electric car charging stations has exceeded 40,000, compared to 35,000 gas stations. But in terms of any other area of development, the imbalances are great here too, even within the EU countries. Having said that, in Romania, in 2016, only 495 electric cars were sold, which is more than twice of the number of cars sold (236) compared in 2014 in this country. The Romanian government hopes to increase the use of electric cars and has announced economic incentive program worth 16.6 billion euros. Money is being offered as a subsidy for companies or individuals who buy an electric or hybrid car, provided that the car produces less than 50 grams of carbon dioxide per kilometer. In its publications, EUROSTAT lists Romania as the last country in the EU in terms of buying environmentally friendly cars. It’s worth mentioning that this is a country where the first charging station for vehicles opened in 2011.

1.1. *The Albanian Market of electric vehicles*

The State Police (2017) reported that 563,106 vehicles of all kinds were in circulation on the roads of Albania at the end of 2016, 401 499 of which performed the compulsory technical control. The Graph. 1 plots an informality rate by 28.7 percent, which has annually decreased. In 2005 from 285,714 vehicles in circulation, only 165,758 had undergone the technical control inspection test. In 2010, 245, 064 out of 420,047 vehicles in circulation underwent the technical control inspection test. In 2015, 376, 028 vehicles out of 522,066 in circulation only had technical control inspection test.

Graph. 1- Albanian vehicle data base, years 2005 – 2016.

Table 2. Number of vehicles technically controlled

No	Vehicle type	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	Scooters	2107	3058	4011	6450	6451	8054	8830	9474	9376	11702	14799	16895
2	Pass. car	119152	126965	140798	149615	161465	173920	191787	209616	232041	264234	288071	308919
3	Microbus	9061	9892	8470	8753	10296	13658	13553	16076	14218	15858	16555	16729
4	Autobus	2826	3125	3107	3413	4042	6640	6601	6968	4035	4349	4173	5152
5	Truck	29451	29012	33058	34625	35144	38651	42891	40910	42848	46008	47912	48338
6	Trailer	2546	2643	2922	3256	3194	3891	4340	2029	3727	3961	4161	4378
7	Tractor (wheel)	615	354	180	147	194	250	198	209	228	292	357	1088
TOTAL		**165758**	**175049**	**192546**	**206259**	**220786**	**245064**	**268200**	**290146**	**306473**	**346404**	**376028**	**401499**

Source: State Police, Ministry of Transportation and Infrastructure

Data reveal a market characterized by a high informality rate and ineffective rule of the law in many cases. On the other hand, both graph and table 2 point out a major expansion of the market, more than twice within a decade. Approximately, 200 million euros are annualy spent on vehicle purchase. Consequently, the concessionaires have been put on competion among themselves. In addition, the used vehicle market that is still dominant in Albania. After the financial crisis of 2011-2013, especially during 2016, citizens have considerably increased their expenditures in buying cars. According to data from Institute of Statistics of Albania (INSTAT) 2017, vehicle imports in Albania in January 2017 increased by 25 percent. Over the period of four months, the concessionaires have sold 1,000 zero-kilometer cars, or about 10 cars per day. From January to April 2017, Albanians spent in total 11.1 billion lek (ALL) or about 83 million euros to buy cars compared to 66 million euros, which was for the same period last year. In addition, the data reported that about 76 percent of the imported cars in Albania are used ones and the number of new cars has also increased.

Considering this trend, the sale of electric cars is expected to grow in the Albanian market. In 2016, Porsche Albania delivered a stock of 11 electric cars to Tirana police, being the first company to offer such an alternative to the Albanian market. "Porsche Albania" has already brought in the country and has for sale some electric car models among which Volkswagen e-Golf and Volkswagen e-up. Electric cars already in use by the State Police were bought by the Electricity Distribution Operator as a project to promote their

market in Albania through a concrete example. Cars are a novelty not only for the State Police, but for the entire Albanian market, although the market expandability is negligible at a time as there are 13 public charging stations, all of them in Tirana inside of Police State building.

What does this example show?

Reality is sad. Preparations for the opening of this market have long been missing. The Albanian Customs office confirmed that there is no change in the clearance of these vehicles (Gazetaexpres- online (2017). In addition, they are taxed the same as all the other vehicles, and policies in this field are totally missing. Consequently, efforts have to be made to improve the situation. However, the initial cost of the electric cars is higher than the cost of cars with internal combustion engines.

Macedonia, one of the Balkan Countries has already started implementing policies about the electric cars.

Since January 2017, the Macedonian government decided to give a bonus to each customer based on the price value of the car: 3,500 Euros bonus for each electric car that costs up to 25,000 Euros and 5,000 Euros for each car that costs over 25,000 Euros. In addition, VAT was reduced from 18% to 5%, free of charge passage on any public road, free parking in every public parking space in the country. 5% of public parking lots (or those with concession) are obliged to install electric chargers. 2 fast and 2 normal chargers will be installed in cities like Bitola, Stip, Veles, Orhrid, Prilep, Kocani, Kavadarci, Gevgelija, Radovis and Kriva Palanka. 4 and 5 stars hotels are also required to have 2 normal chargers in the respective parking spaces. Electric cars will be allowed to travel on the reserved lanes (like that for the buses). Also in 2017, highway fuel stations across the country will have 1 fast charger for electric cars. In 2018, all these stations should have 2 fast chargers. In 2019, all fuel stations in inter-city roads must have at least 1 electric charger.

2. Comparative analysis of EV

The last decade is characterized by a progressive growth of the electric vehicle market. Yet, many companies and individual consumers are not attracted to them due to the lack of the marketing elements, the pressures of the traditional market and the big oil producers, economical and environmental benefits of EVs. The reminder of the paper reports on benefits and disadvantages of such cars and draws conclusions.

2.1 Advantages

2.1.1 **Lower cost**

Electric vehicles have a significantly lower cost of operation. At a time when the price of fuel is dependent upon political factors and market on juncture, electricity price is more stabilized and renewable energy resources are of the greatest interest to the technology companies, thus creating even greater opportunities for the decline of cars with fuel.

Data report that in many countries, the average distance that vehicles cover in a year is between 10,000 and 15,000 kilometers. The analysis of the costs and benefits of using electric vehicles EV and the the fuel operating ones is based on the number of kilometers done. The following calculations do not include the possibility of state incentives at the time of purchase or other incentives during their use. The table 4 and 5 clearly report the big difference between the purchase prices of the two models. where the difference is about 10 thousand euros. But this gap closes gradually over years by considering fuel consumption costs, which for EV are very small.

According to cost estimates of the Volksvagen e-up model (traded in Albania too), made by the concessionaire that sells these cars, it results that the costs, initially in favor of the traditional vehicles, are equated after four years of using a new purchased vehicle. After this period, considerable benefits start resulting from lower fuel and maintenance costs. Based on those estimates it turns out that except from the purchase price, in that case with a difference of 14 thousand euros, all the other indicators speak in favor of the electric vehicle. So, while for a traditional car, the cost of fuel supply per 100 kilometers is 5.4 EUR, for an electric car, this cost is only 0.80 EUR. On this basis, it is estimated that for 100,000 kilometers an electric car consumes only 800 euros, against the 5400 euros consumed by the traditional fuel car. Comprehensive reports also include maintenance costs. The Volkswagen e-up needs 700 euros per 100 thousand kilometers, while its fuel model requires 3000 euros.

Table 4. Costs calculationVolkswagen e-up! (electric) VS Volkswagen combustion up! 4 years – 100,000 km

	e-up! automatic 82 HP (electric)	**up! 1.0 MPI automatic 75 HP (combustion)**
Price in EUR	27,700	13,600
Consumption / 100 km	11.7 kwh	4.2 L
Costs per 100 km in EUR	0.80	5.4
Costs per 100,000 km in EUR	800	5400
Maintenance per 100,000 km in EUR	700	3000

Source: Volkswagen Group, Porche Albania

Photo.1. Volswagen e-up car and charger station in Tirana (Albania) of Porsche Albania
Source: Porche Albania

It has been considered that this calculation serves for another type of car too. According to an estimate made by Mercedes-Benz and quattroruote.it for the electric Smart (fourtwo) Coupe and Smart (fourtwo) Coupe with gasoline, apart from the initial price of 10 thousand euros in favor of the traditional car, all the other indicators are in favor of the electric car. So, for a full charge of the vehicle in the case of the eclectic car the cost is 1.23 euros (according to the prices in Albania) against 42.75 euros needed for a gasoline filling. Using the estimated cost per kilometer, it results that the benefit ratio in favor of the electric machine is five to one.

SMART fortwo ELECTRIC **SMART fortwo GASOLINE-1000 52 kw MHD**

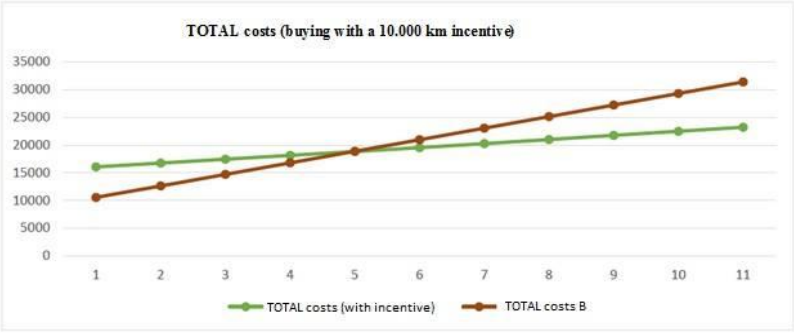
Table 5. Comparison of Costs for Smart Cars

	SMART fortwo ELECTRIC	**SMART fortwo GASOLINE**
BUYING PRICE €	20,086	10,551
CONSUMPTION & TECHNICAL DATA		
Energy capacity / full tank liters	17,6 kwh	33 lt
Costs € / kwh & € / lt	0.07	1.29
Costs of full tank	1.23 €	42.75 €
Autonomy in average speed	145 km	630 km
Costs per km	0.008 €	0.070 €

Source: Merecedes-Benz/quattroroute.it
Cost of kw/h: Albania Energy Regulator Authority
Cost of Gasoline: Ministry of Finance
Exchange rate from ALL to Euro €: Bank of Albania

Based on the above calculations, where costs are equated to at least 5 years, the benefits of using electric cars are great. However, this also depends on another indicator; the number of kilometers the vehicle makes. On this basis, the years are in an iverse proportion with the kilometers performed by the vehicle. In the following tables where calculations for an annual mileage of 10 thousand and 15 thousand kilometers are made, the intersection of two lines represents the progress of the expenditure (green for the electric vehicle and brown for the petrol vehicle). They start with a large margin, created by large initial cost, in favor of the gasoline-powered vehicle which is gradually overcome (graphic 6 and 7).

Graph 6. Costs for 10 thousand km.



Graph 7. Costs for 15 thousand km.
Source: quattroruote.it

The two graphs plot the benefits of the EVs after five and four years, respectively. So, it is estimated that the electric car brings a savings of 10,000 euros from the fourth year to the tenth year of use. But the big gap between the two purchase prices may be amortized within few years due to appropriate policies.

2.1.2 Quick and secure

The latest speed records have been marked from electrical vehicles. For example, the S P100D model from Tesla reaches 100 km / h at 2.28 seconds, making it the first car of a production line that reaches 100 km / h in less than 2.3 seconds. This is because EVs offer superior proportion of power-weight ratios compared to traditional cars. Moreover, electric motors provide instantaneously greater amounts of power available. Even relatively poor electric motors usually accelerate faster than the engines similar in power that use Diesel or Gasoline. At the same time EVs are far safer than internal combustion engine cars. It is practically impossible for a battery powered vehicle to explode because of the collision; and because the battery pack significantly reduces the EV mass center, the vehicle has less chance of rolling. The manufacturers of EV have not spared the cost of building security systems and therefore these vehicles regularly pass security standards.

2.1.3 Easy to maintain

Diesel or gasoline engines have a long list of maintenance costs where changing oil and filters is top list, and other transmission-oil change, brakes-oil, belts, battery switches, air filters etc. Electric vehicles come with less maintenance requirements and therefore maintenance costs are much lower. "The electric engine has a moving part, the axis, which is very reliable and requires very little or no maintenance. Controller and charger are electronic

devices without moving parts which require little or no maintenance. In their periodic checks and their services electric vehicles are limited only to the change of the air conditioner filter, which means no more engine oil and oil filter, fuel filter and air filter for the engine. Replacement of the brake pads takes a period three times longer than in normal vehicles because the moderate braking is performed through the electric engine. The battery pack has a long-lasting warranty too.

2.1.4. Opportunity for Subsidy

Most local governments provide financial subsidies for consumers who buy EVs. For each new EV in the US is given a $ 2,500 to $ 7,500 credit. However, the exact schemes and amounts given to individuals are available on official government websites. Numerous facilities for purchasing an electric car are also being created in all European countries. But unfortunately, Albania is not on this list yet.

2.1.5. Environmentally friendly

EVs do not emit gasses from the exhaust pipe, which are known to be a serious threat to human and environmental health. For example, an average fuel car produces over 560 grams of CO_2 per kilometer. Regarding emissions, calculations are simple: 1 new diesel car emits approximately 130 g CO_2 per kilometer. If this car makes 15,000 kilometers a year it emits 1,950 kg CO_2. For each electric car sold, approximately 2 tons of emited CO_2 is reduced every year. Put in another way to remove the same amount of CO_2 per year approximately 90 grown trees are needed. In Albania where electricity is generated through renewable sources, CO_2 would not be produced for car charging. Noise pollution is also detrimental to public health, and the internal combustion engines of petrol / diesel, fuel vehicles are some of its sources. At a speed of 100 km / h, the average noise of an internal combustion engine is 70 dB, compared to an almost "whispering sound" that is produced by an electric car in the same conditions. According to a study by the National Institute of Environmental Health Sciences, millions of citizens have Health problems due to exposure to noise, including heart disease and hearing loss.

3.2. Disadvantages

3.2.1. High initial cost

Electric vehicles to date are much more expensive than their similar prototypes that operate with diesel and gasoline. Differences in initial prices go up 10,000 euros or more. Due to this drawback, manufacturers of these cars plan that within 2022 they can equate prices due to long-term investments. However, regardless the high costs, electric vehicles are of great

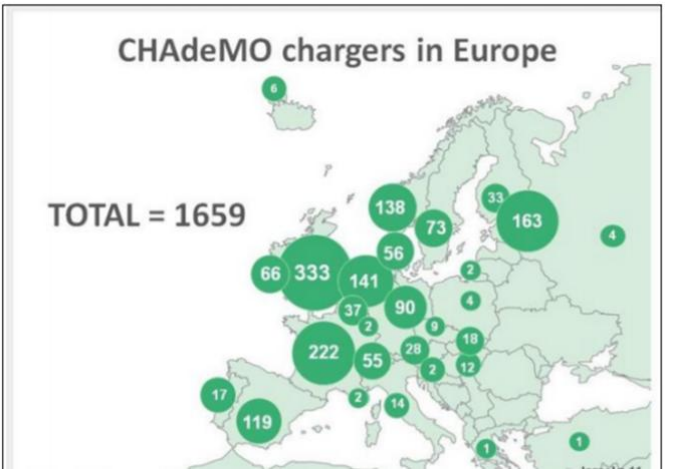
economic and environmental benefit due to fuel savings and little maintenance costs.

3.2.2. Low autonomy

The initial price is not the biggest disadvantage of electric cars. The biggest disadvantage of EV is their limited amplitude, known as "range anxiety" / "anxiety of autonomy". So, a 2016 Nissan Leaf model travels up to 180 miles with a single charge. But this is a high figure. The idea that you will travel only 150 miles with a single charging is very disturbing to potential customers who think that this traveling amplitude is limited. However, improvements are being made in this direction too. Cars with significantly higher amplitude have been produced recently such as: Tesla Model S & Model X with 400 km amplitude, Tesla Model 3 with 350 km amplitude, Chevrolet Bolt - 380 km and in 2018 Nissan Leaf promises amplitude of 320 km. An intermediate solution is the HEVs (Hybrid Electric Vehicles) which, instead of waiting for technology to improve, hey thave added fuel tanks. A Chevrolet Volt, for example, offers 85 kilometers of electric travel amplitude, and a fuel tank for longer trips.

3.2.3 Lack of infrastructure

As aforementioned said, Japan is the only country in the world where the number of electric car charging stations exceedes that of fuel stations. But this is just an exception. Although very rapid improvements have been made, the current charging infrastructure of electric vehicles leaves much to be desired. A Report on Charging Infrastructure - EV issued by Information Handling Service (IHS) predicts that the number of car charging stations in the world will increase from more than 1 million units in 2014 to more than 12.7 million units in 2020. In 2015, there were 1659 charging stations in Europe(map1). In 2017, the number of charging stations doubled. Meanwhile, according to the Volksvagen concessionaire in Albania, there are 13 electric cars charging stations.



Map 1. Charging stations in Europe
Source: IHS

The charging of electric vehicles be a convenience too. They also offer the possibility of car charging either at home or on parking lots. Great improvements have also been made in this regard. Currently, the fastest EV way of charging is known as the Rapid DC Charge, through which most EVs reach 80 percent charging in 30 minutes, compared to 8 hours that is the standard charging time of a common battery.

3.2.4. Less Choice Opportunities

New electric vehicles are being introduced almost every week, but it will take years until customers have the possibility to choose as they do from the same range of models they can find when it comes to traditional internal combustion engines.

4. CONCLUSIONS

Is it worth?

The electric car (EV) is a relatively new concept in the world of the automotive industry. They are cost effective**,** safe and envornmental friendly. In addition, they have reduced noise pollution and low mantainance costs. Although this technology is still new, the advantages of electric vehicles tend to be considerably greater than the disadvantages in many scenarios. Although the progress made in recent years regarding electric batteries has been made uncertainty remains high. Engagement of multiple investments by electric car dealers promises even greater improvements, ultimately resulting in further reduction of costs. In this regard, the benefits are tangible even at present.

But public, international, national and local authorities have their own job to do. Based on what was said above, electric vehicles EVs should be the object of legal changes, by preparing tax and non-tax incentives to promote their market. So far this has only happened in some countries such as Norway, California, the Netherlands, the UK, France and, finally, China. Unfortunately, Albanians are still waiting.

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Taxation is a means by which governments finance their expenditure by imposing charges on citizens and corporate entities as one of the financial resources provided to the state and has an impact on the distribution of income.

Scientific information

Lately, the first volume of the Flora Albanica Atlas authored by Acad. Jani Vangjeli has appeared in print by the Koeltz Botanical Books, Germany. This book is an added value to the previous books published in the area by the same author and his colleagues- the Flora of Albania, Dendoflora of Albania, some regional floras, the Field Guide of Albanian Flora and the Excursion Flora of Albania.

The book makes a considerable contribution to Albanian science, with both scientific and practical importance in several key areas such as forestry, pastures, aromatic and medicinal plants, pharmaceutics, lexicography etc.

In this volume are included about 1700 species of spontaneous and cultivated plant species, information for the most of which could be found in "Flora of Albania" (1988-2000), but also many new plants found in recent years by Albanian and foreign botanists, and reflected in the work Excursion Flora of Albania.

The focus of the 931-page book is on distribution maps, together with lists of specific locations where the plant was found over the last 80 years.

The data are obtained from plant specimens of the National Herbarium and from about 120,000 entries in the data base, which includes data from both foreign as well as native literature.

The scientific and popular names used in Albania and Kosovo are provided as well as the abbreviations of biological forms, month of flowering, chorology, respective locations, coloured photographs, the categories and criteria of the IUCN-Red List and distribution maps for each single plant species.

The book is rounded off by an Albanian and Latin index of species and families.

A complete list of the books offered by the German Publishing House could be found at www.koeltz.com.

OBITUARY

September 1943-April 2017

PROF. DR. ARQILE BËRXHOLI – EMINENT PERSONALITY OF EDUCATION AND GEOGRAPHY

ARQILE BËRXHOLI was born in Këllëz, Lunxhëria, Albania in 1943 and attended pedagogical highschool in Gjirokastra. He graduated in history-geography from the University of Tirana in 1967 and worked as teacher of geography in his home town. He was appointed professor of economic geography of Albania and demography of Albania at the Faculty of History and Filology, University of Tirana from 1967 to 1991. He was the Vice-Dean and Dean of this faculty from 1987 to 1991. He was appointed head of the sector for social geography in 1991 and Director of the Center for Geographic Studies of the Academy of Sciences of Albania from 2000 to 2008.He was appointed professor at the University of Elbasan in 2008 until his retirement. He also was part of the academic staff at the University of Tirana, Gjirokastra, Shkodra, Prishtina, Skopie etc.

He made possible the cooperation with the University of Bamberg, Germany. This cooperation continues and relates to expeditions, scientific activities and mutual scientific publications.

His teaching capacities draw the attention of many generations and his intelectual capacities were a source for the compilation of many academic programs and maps.

His contribution to the pedagogy and scientific research is clear. Prof. Bërxholi is the author of many scientific publications and curricula and head of scientific research run in the protected areas of Albania: “Economic geography of Albania” (1984), “The changes in the geography of the Albanian population of the region Vjosa River–Jonian Sea” (1987), “General registration of Albanian population” (2000), “Knowledge on demography” (2001), “Minorities of Albania” (2005), “Lunxhëria - population, settlements, economy” (2007). In addition, he is the co-author of “Albanian population” (1987), “Geographic Atlas of Albanian population” (2003) etc. He wrote

many articles for the newspapers and compiled thematic atlases and maps to foster this scientific area.

His last publication is“The encyclopedia of Gjirokastra”, his hometown. He was one of the founders of Lunxhëria Association.

It has been said that this science area will not be the same without him

He was a likeable and approachable and inspiring man who will be much missed for his humbly nature.

Prof. dr. Vasil Kristo
Prof. dr. Perikli Qiriazi
Prof. dr. Dhimitër Doka
Prof. dr. Bilal Draçi
Prof. dr. Skënder Sala