# AN INVESTIGATION OF THE POTENTIAL APPLICATION OF BAUXITE RESIDUE IN SOIL / SEDIMENT REMEDIATION

**S.P. VARNAVAS, * D. BOUFOUNOS**, and D. FAFOUTIS****

* Department of Geology, University of Patras, Patras Greece.
** Aluminium of Greece, S.A., Saint Nikolas Boiotia, Greece.

## EXTENDED ABSTRACT

A series of laboratory experiments have been carried out using bauxite residue in order to investigate the possibility of its use:
- in soil / sediment remediation
- in soil / sediment stabilization.

For this aim mixtures of bauxite residue with a variety of soil types were studied under various ratios. Carbonate soils of various $CaCO_3$ content and various pH as well as silicate – rich soils / sediments were used. The investigation of the mixtures included pH measurement and their leaching with rain water and analysis for important elements. The above measurements were carried out :

a) immediately after the mixing of the bauxite residue samples with the soil samples,
b) three days after the mixing,
c) thirty days after the mixing.
Similar leaching experiments have been carried out using $CH_3C000Na$.

Other experiments included interaction of bauxite residue under various ratios with soils of low pH, contaminated soils adjacent to major roads and organic rich soils. Also, in other laboratory work the above experiments were carried out in the presence of gypsum and/or organic material.

The results of this work are very encouraging. There are important indications suggesting that under certain conditions, after assessing the specific physicochemical conditions in the soils/sediments and examining all the limiting factors, bauxite residue can be used for soil/sediment remediation. However, for field operations further work is needed using the bauxite residue in plant and tree development. Our research is continued towards this direction.

**Key words :** bauxite residue, remediation, pH, soil.

## 1. INTRODUCTION

Bauxite residue is the waste produced in alumina processing plants during alumina production, using the Bayer method. Recent investigations on the physical and chemical properties of Greek bauxite residue showed that it consists of 6.2% SiO2, 16.3% $Al_2O_3$, 11.1% CaO, 45.3% $Fe_2O_3$, 0.5% MgO, 0.1% $K_2O$, 3.1% $Na_2O$, 4.9% $TiO_2$. It is very fine material with 85% of its grains being below 63 μm, while its density is 3.4 gr/cm$^3$. The main minerals / compounds identified in bauxite residue are haemitite, alumina, quartz, calcite, perobskite, gypsite and diaspore [1].

Previously, several studies have been carried out on the industrial applications of bauxite residue [2-4]. An interesting study is that on the application of bauxite residue as basic component of new construction materials [1, 5]. Other studies were on the application of bauxite residue on acid nutralization and treating acid sulphate water and soils [6].

The aim of this work is to investigate the potential applications of bauxite residue in soil/sediment remediation, soil/sediment stabilization.

## 2. RESULTS AND DISCUSSION

A series of investigations have been carried out which included interaction of bauxite residue with acid soils, saline soils, organic rich material and silicate soil.

An important condition for the function of normal soil is the appropriate pH condition. Therefore, a series of experiments with mixtures of bauxite residue was carried out with aim to achieve appropriate pH condition in the soil.

### 2.1. Experiments with silicate soil

In these experiments mixtures of bauxite residue with silicate soil were studied in the following ratios 1 : 1, 1 : 2, 1 : 3, 1 : 4.
pH measurements were carried out :
a) three hours after mixing
b) three days after mixing
c) thirty days after mixing.

The results of these measurements show a tendency for pH to decrease with time. Particularly in the third measurement the pH decrease is very characteristic.

In an attempt to simulate the field conditions, fresh natural rainwater was collected, which was used in the above measurements.

It is noted that in the fourth experiment (with 25% bauxite residue) pH drops down to 8.52.

### 2.2. Experiments with different types of soils and organic rich material

Further experiments were carried out mixing the bauxite residue with different types of soils, gypsum and organic rich material.

The results are shown in Table 1. It is interesting to note that in the experiment with soil B in the mixture bauxite residue : soil : organic rich material under ratio 4 : 2 : 2 a 7.35 pH is achieved. (Fig. 1)

Under the same ratio in sample D pH drops down to 7.14, while under ratio 4 : 1 : 2 pH is 7.74.It is therefore seen that in soils normally encountered in the environment the ratios soil : bauxite residue : organic rich material important ratios for appropriate pH conditions are 4 : 2 : 2 and 4 : 1 : 2.

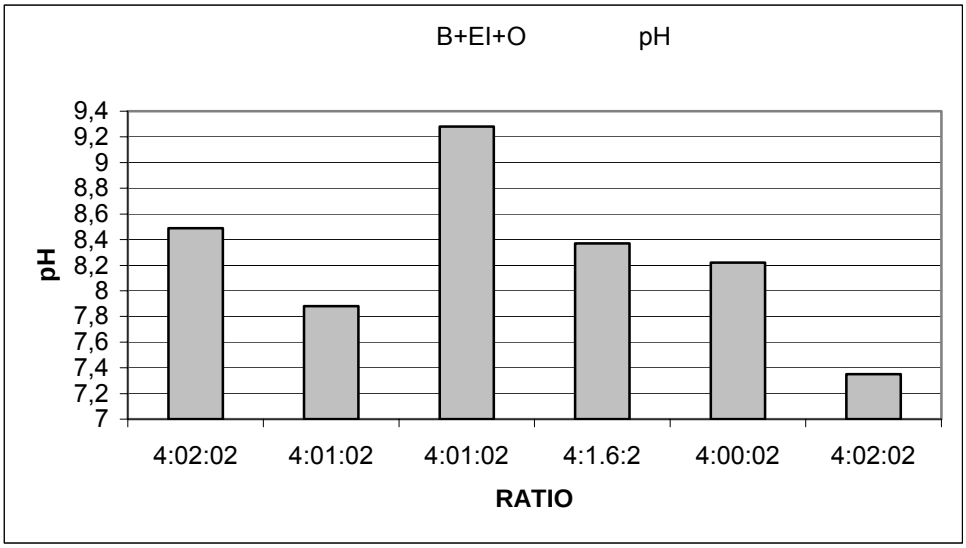


**Fig. 1.** Variability of pH in soil after its interaction with bauxite residue and organic rich material under various ratios (B : soil, EI : bauxite residue, O : organic material)

### 2.3. Experiments with soils of low pH

In order to investigate the potential application of bauxite residue in the improvement of soils with low pH, bauxite residue interaction experiments have been carried out as follows : i. mixtures of bauxite residue with low pH soils, ii. mixtures of bauxite residue with low pH soils and organic rich material.The results of these experiments showed that the ratio soil :bauxite residue : organics, 4 : 2 : 2 gives pH 6.95, while 4 : 1 : 2 gives pH 7.46 ( Fig. 2).

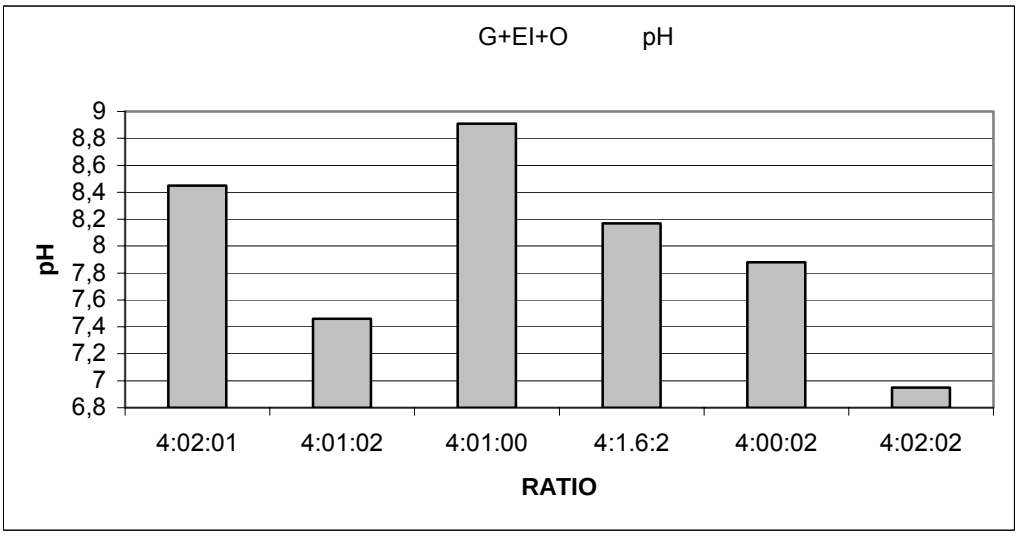


**Fig. 2.** Variability of pH in soil of low pH (G) after its interaction with bauxite residue (EI) and organic rich material under various ratios.

Further,to study the improvement of soil conditions in acid soils in the presence of bauxite residue, the following mixtures were studied in various ratios :soil :bauxite residue: gypsum: organic rich material.The results are shown in Fig. 3.

It is seen that pH conditios between 7.46 and 7.98 were achieved when all four compounds are mixed. However, it is interesting to note that in a ratio 4: 2: 2: 0( without the presence of organic rich material) pH is slightly higher.

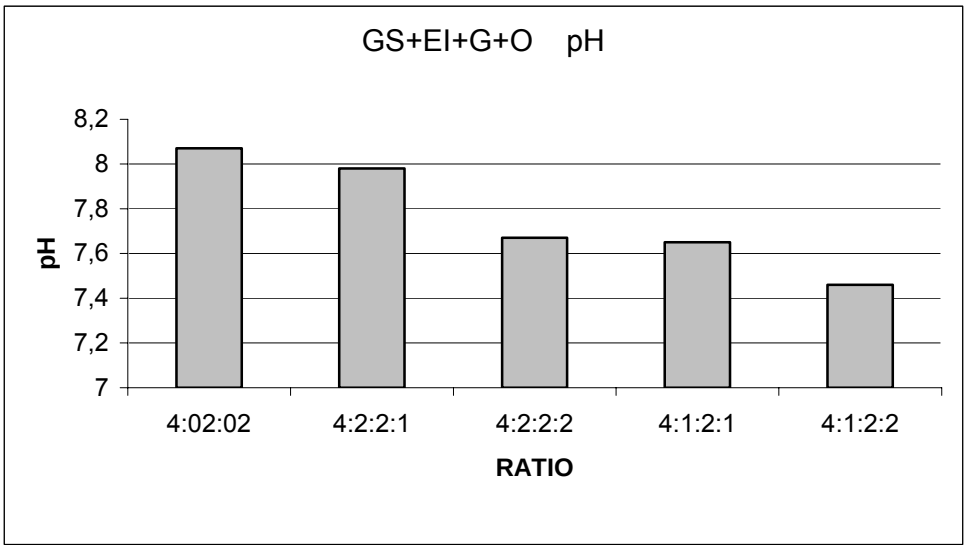


**Fig. 3.** Variability of pH in soils of low pH (GS) after its interaction with bauxite residue (EI), gypsum (G) and organic rich material (O) under various ratios.

### 2.4. Experiments with saline soils

The experiments with saline soils showed that important ratios for soil : bauxite residue : organics are 16 : 1 : 5 which give pH 7.83 and 16 : 1 : 4 which give pH 7.98. (Fig. 4)

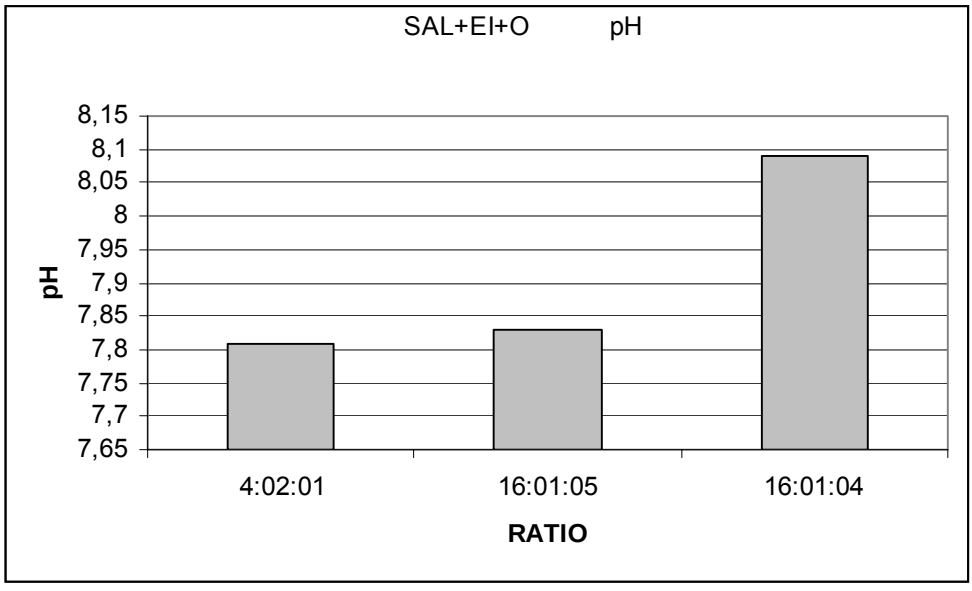


**Fig. 4.** Variability of pH in saline soil (SAL) after its interaction with bauxite residue (EI) and organic rich material (O).

### 2.5. Experiments with different types of soils, gypsum and organic rich material

Most of the experiments described above were carried out by addition in the mixture, except for organic rich material, gypsum also (under various ratios). The results show a similar / or further drop of pH. It is concluded that both materials organics or gypsum can be used, where it is feasible (and considering the chemical composition of the soil). ( Fig. 5).

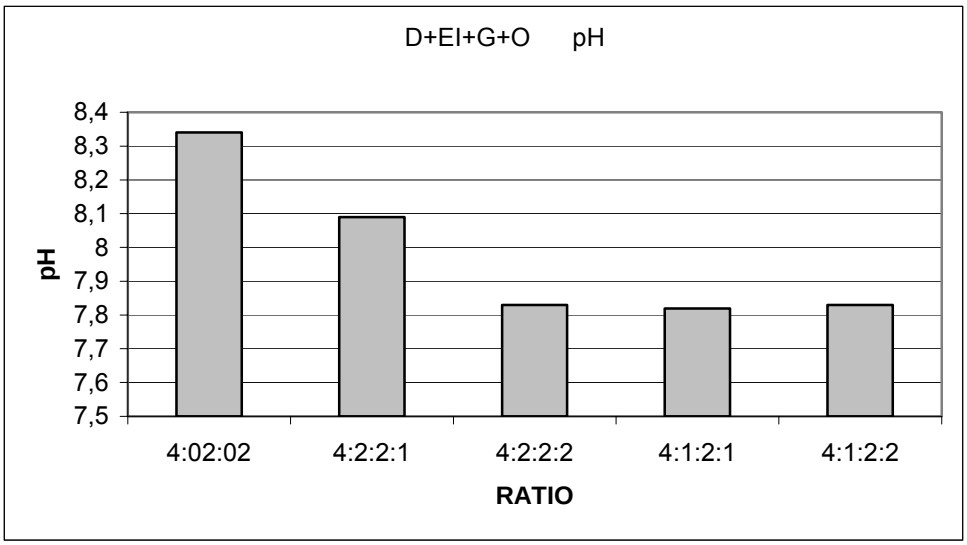


**Fig. 5.** Variability of pH in soil (D) after its interaction with bauxite residue (EI), gypsum (G) and organic rich material (O).

### 2.6. Experiments with organig rich material

In these experiments bauxite residue was mixed with oganic rich material under various ratios.pH measurements showed drastic decrease in pH.
The results are shown in Fig. 6.

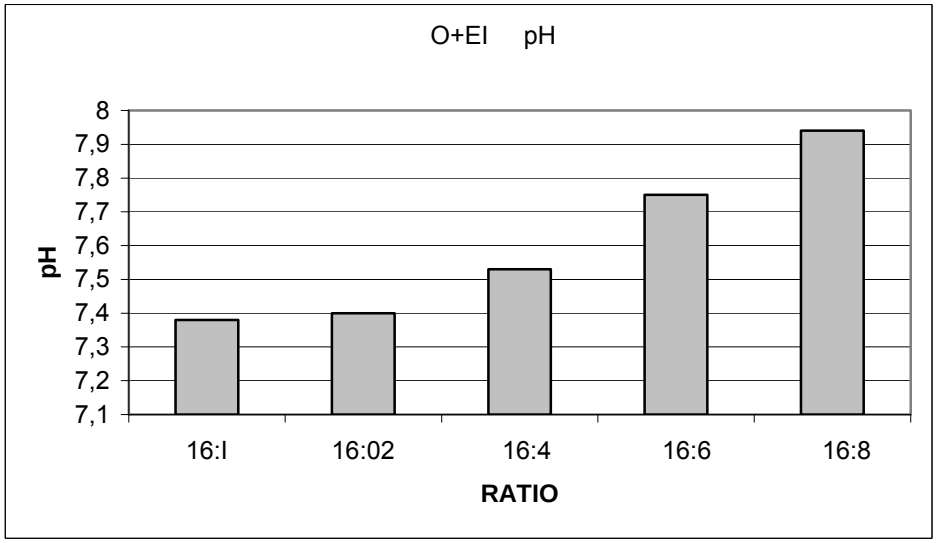


**Fig. 6.** Variability of pH in bauxite residue (EI) after its interaction with organic rich material (O) under various ratios.

## 3. CONCLUSIONS

The results of this work show that under certain conditions the properties of bauxite residue potentially can allow its use for improving soil conditions. For example nutralization of acid soils can be achieved, particularly where very low pH is encountered. This facilitates the vegetation development which in turn prevents soil weathering. The exact soil : bauxite residue ratios under which soil improvement can be achieved were determined. Similarly, the soil-bauxite residue interaction experiments with different types of soils (i.e. silicate, carbonate, organic, rich e.t.c.) showed the ratios under which appropriate pH conditions can be achieved for vegetation growth.The analysis of the wet phase of the above interaction experiments showed the presence of only minor amounts of trace metals. Although this needs further investigation the results of the whole experimental study are very encouraging. The conclusions of this work are in consistence with other studies on the application of bauxite residue for soil improvement.

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