Misr J.Ag. Eng., 19 (1): 113-122

Exploitation of Clay from El-Maghara Coal Washing in Land Reclamation

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ABSTRACT

Treatment of wastes can be helpful for different fields such as environment, industry and cultivation. The treatment of wastes of El-Maghara coal washing plant by flotation was done in a previous work in order to recover the fine coal from the filter cake. A considerable amount of clay was produced at the end of flotation process. The main objective of this work is to use the resulted clay as a mud layer for sandy lands in Sinai to improve it and to make it suitable for cultivation of some strategical crops. Different types of soil, namely, filter cake soil (without treatment), the residual clay (the tailing produced after the treatment of the filter cake by flotation) and Nile valley soil were investigated and compared. In this regard, wheat was selected and investigated in such soils. It was found that the reclamation of sandy lands is possible by mixing the surface layer of sand bed with the clay produced from the waste of El-Maghara coal washing plant.

I. INTRODUCTION

Treatment of wastes for reuse of their constituents becomes a main strategy to keep the environment as clean as possible. The filter cake produced from El-Maghara coal washing plant is one of these wastes, which occupies a wide range of concern. This kind of waste represents about 112,000 ton/year. Along the mine age, which is about 35 years, a huge amount of filter cake will accumulate in the storage area near the mine. This waste was found to contain more than 45 % fine coal and the remainder as clay. It was suggested to recover this amount of fine coal by flotation technique. The obtained yield of fine coal was found to be about 50 %. Hence, a considerable amount of clay, i.e., about 56,000 ton/year will be collected. The recovery of coal fines from this waste can be helpful in two folds, the first, is the possibility of using the recovered coal fines in different purposes where, its specifications were found to be encouraging (Ramadan et al., 2000). The second is the attempt to use the residual clay in brick industry as suggested by Ramadan et al., (Ramadan et al., 2000). The selectivity and the recovery of fine coal flotation systems were improved by mixing different types of collectors (Saleh et al., 2000; Felicia, 1996; Lui and Somasundaran, 1994; Chander et al., 1994; Bonner and Aplan, 1993; Raleigh et al., 1990). In this respect, it was found that kerosene is a good cheap collector to recover the fine coal from its tailings (Saleh et al., 2000).

The optimum conditions indicated by Ramadan et al (Ramadan et al., 2000) for separating the coal fines from the wastes of El-Maghara coal washing plant were applied in this investigation. The residual clay produced from the treatment process was investigated in a preliminary attempt to use it as a mud layer for the sandy land to improve its ability for cultivation.

It is well known that sandy lands contain less than 10 % of silt and clay. In order to reclaim these sandy lands, their specifications should include the following properties, its particle size should be small enough and such bed should be deep and far away from the solid bed (Moursy and AbdEl Gawad, 1966; Kamel and Rehab, 1982).

Different types of soils, namely, filter cake soil; the residual clay soil and Nile valley soil were investigated with wheat plant. The residual clay was mixed with sandy land at different ratios. In this regard, a winter crop (wheat) was selected to test the response of these soils for cultivation.

II. MATERIALS AND METHODS

Denver flotation cell was selected as an experimental appliance in order to separate fine coal from clay tailing. Although this type of flotation machine has a self-inducing aerator, in which the air flow rate is dependent on the impeller speed, the air flow rate to the machine was controlled by using a rotameter as shown in Fig. (1).

The optimum conditions, indicated by Ramadan et al. (Ramadan et al., 2000), for separating the coal fines from the wastes of El-Maghara coal washing plant were applied in this investigation. The residual clay was collected and used as a mud layer in all cultivation experiments. The x-ray analysis was done for the waste sample and the results are shown in table (1). From these results it was found that high percentage of Al_2O_3 (13.36 %) and high percentage of coal fines, (L.O.I = 52.01 %) existed in the head sample of filter cake.

Table : (1) X-ray analysis of filter cake sample
(Ramadan et al., 2000)

Constituents	Content %
SiO_2	26.10
TiO_2	1.5
Al_2O_3	13.36
Fe_2O_3	3.97
MnO	0.03
MgO	0.55
CaO	1.37
Na_2O	0.14
K_2O	0.92
P_2O_5	0.05
LOI	52.01
Total	100 %

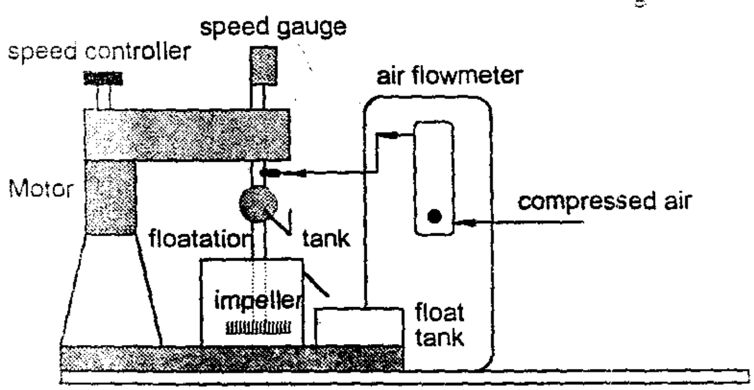

Fig. 1 Experimental Setup of flotation cell

The considered batch system consists of tab water, collector, frother, filter cake and air. Kerosene was used as a collector and pine oil at constant concentration of 60 mg/l was used as a frother.

The experimental procedure for the separation of coal fines from the waste sample includes 5-min agitation, 5-min. collector contact, and 1-min. frother contact and 4 min. flotation time. The collected clay was put in tanks to get rid of decanted water and to use it as a silty layer to test its effect on the reclamation of sandy land.

A sample of sand, from Sinai, supplied by Sinai Manganese Co. was used to prepare the sandy layers in the laboratory. The chemical and sieve analyses for such sand sample are shown in tables (2) and (3). A wheat plant was selected as a winter crop to test the response of tested soils for cultivation. Twelve plastic pots each having 20-cm diameter and 15-cm depth were prepared for cultivation process. With respect to the experimental part, which concerns with the cultivation process, it is carried out in four sets of experiments. The first set deals with the effect of different soil types on the wheat growth. These soil types were Nile valley soil (from delta region), the waste as it is received from the coal washing plant, and clay tailing which produces as a tailing after the treatment of the coal washing plant wastes by flotation. The Nile valley soil was selected in such set of experiments for comparison with other soils. The second set of experiments dealing with the effect of mixing the waste as it is with sand. This set of experiments is mainly dependent on the mixing of the waste sample with sand at different ratios by weight in the pots. The third set of experiments is similar as the second one but with the clay tailing as a mixed soil with sand at different ratios. The last set of experiments is conducted to investigate the effect of depth of a suitable selected mixture, from the results obtained, on the wheat growth.

The wheat type was selected from the common types in Egypt (Sakha 71). It was delivered from an agricultural society in Ismailiya. From 10 -12 seeds are distributed in each pot area at a depth of 2 cm. All pots are put in an open air in order to complete the vegetation process under normal weather conditions. The seedtime was selected at the same seedtime for wheat cultivation in Egypt ,i.e, at about the half of November. The irrigation system for pots was conducted as three times weekly. The plant growth was measured every 15 days for a period of 75 days to illustrate the effect of different conditions of soil on the wheat growth.

It is important to mention here that the measurements of the wheat growth were stopped after 75 days, i.e., before seeding of wheat, where it was found that the studied growing period is enough and sufficient for the subject of this paper.

Table (2) Chemical analysis of sand sample

Constituent	Content, %
SiO_2	94.86
CaO	1.28
MgO	0.68
Fe_2O_3	0.33
TiO_2	0.73
Al_2O_3	2.12
Total	100

Table : (3) Sieve analysis of sand sample

Size Fraction, μm	Wt., %
+ 1000	57.67
- 1000 + 500	29.97
- 500 + 355	4.37
- 355 + 250	4.19
- 250 + 125	2.47
- 125 + 90	1.19
- 90	0.14
Total	100

III. RESULTS AND DISCUSSION

1. The effect of applying the optimum conditions on the removal of coal fines from the filter cake

The optimum conditions indicated by Ramadan et al. (Ramadan et al., 2000) for the removal of coal fines from the filter cake were applied at different collector dosages in order to determine the optimum collector dosage for the separation process. These optimum conditions are shown in table 4 and the results obtained by applying them in flotation process are shown in

Fig. (2). As can be seen from this figure, the coal recovery was found to increase by increasing the kerosene dosage. The increase of kerosene dosage of more than 3 kg/t did not cause a considerable change in coal recovery. On the other hand, the ash content changed in the range of 17 to 21 %. The best flotation recovery of fine coal is obtained at about 3 kg/t kerosene. This may be due to the best adsorption of kerosene on the coal surfaces, which makes the coal surfaces more hydrophobic. This, in turn, may be lead to strong attachment between coal surfaces and air bubbles. So, determining the suitable collector dosage (3 kg/t) completes the main frame for the best operating conditions.

Table (4) the applied optimum flotation conditions

pH value	6
Agitation speed, rpm	1000
Solid / liquid ratio by weight	10
Gas flow rate, l/min	6

From the results obtained, it was found that the residual clay tailing has about 78 % ash content. This means that it still has about 20 % of coal fines. The water reservation of such clay was found to be 33 %, i.e., it has very low porosity.

2. Effect of soil types on the plant growth

The effect of soil type on the wheat plant growing rate is indicated in Fig. (3). From this figure, it is clear that among the investigated soil types, the Nile valley soil gave a higher rate of plant growing. This is because this type of soil almost contains all nutrient elements necessary for plant growing. On the other hand, the results obtained from the soil of filter cake (the waste as it is) was found to be slightly encouraging. This can be attributed to the slightly coarse size fractions of coal included in the soil of filter cake. These slightly coarse size fractions play a vital role in aerating the soil providing the plant roots with the necessary oxygen for plant growing. In spite of the used clay soil is more rich in nutrient elements, which is necessary for plant growing, than that contained in filter cake soil, the results obtained in the case of clayey soil were found to be disappointing. This may be due to the very small porosity of such clay, which leads to suffocate the roots of plant by preventing the oxygen to reach to them. Hence, it is expected to obtain good results with such clay soil if it is mixed with sand because sand may increase the porosity of such clay and give a chance for oxygen to reach to the plant roots.

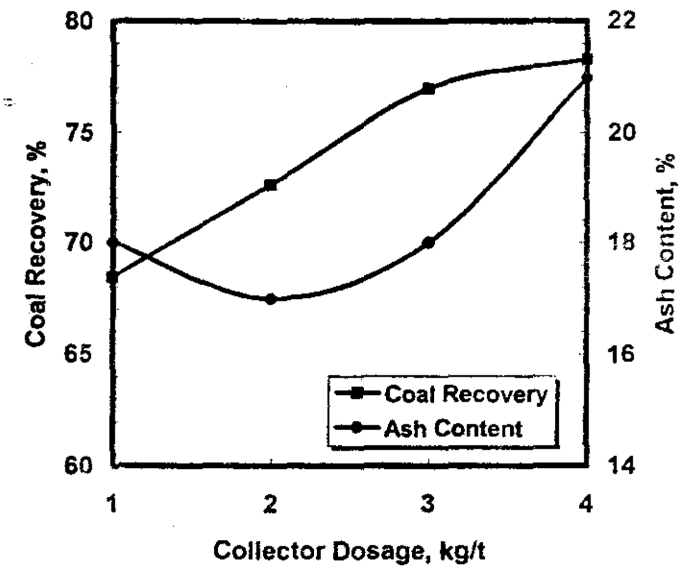

Fig. 2 Effect of collector dosage on the coal fines recovery from the filter cake (the waste).

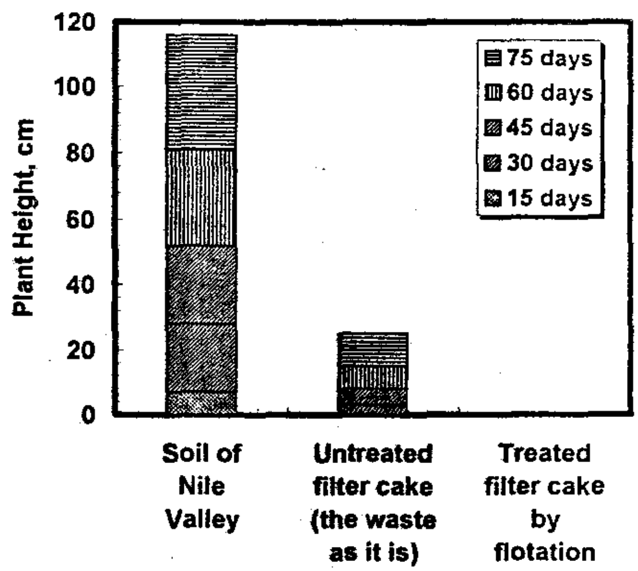

Fig. 3 Effect of soil types on wheat growth.

3. Effect of weight percent of sand on the plant growth

The effect of mixing the filter cake soil (the waste as it is) and the clay soil (produced after the treatment process of filter cake by flotation) with sand at different ratios is illustrated in Figs (4 and 5). It can be seen from these two figures that the clay soil gave encouraging results and high rate of plant growing more than that obtained with filter cake soil. This may be due to the higher percentage of clay in the clay soil type (about 78 %) which contains higher values of nutrient elements for plant growing. This type of soil (clayey) has only one problem represented by its low porosity. So, when the sand is mixed with this soil, the plant growing rate was found to increase as shown in figure (5). Also, it is clear from these two figures that the plant growing rate was found to increase by increasing the weight percent of sand in the mixed layer. This means that little amounts of clay can improve the fertility of sand soil, which in turn, can lead to increase reclaimed area.

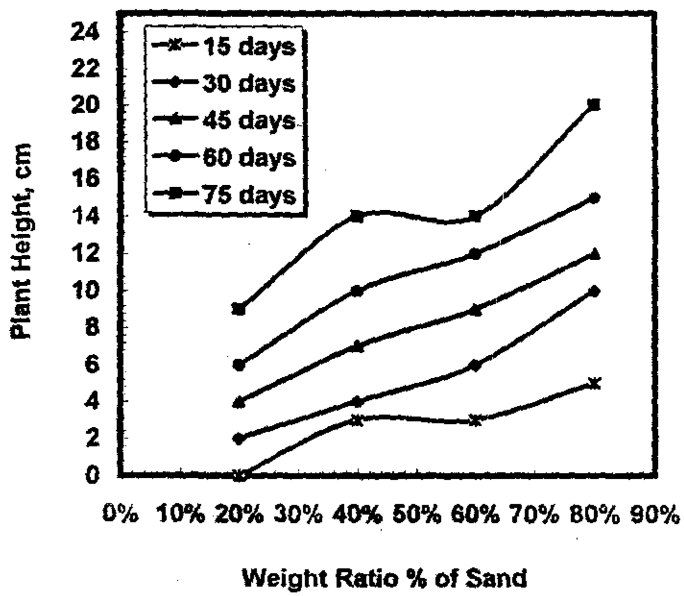

Fig. 4 Effect of weight percent of sand on wheat growth in the case of filter cake (the waste as it is).

4. Effect of mixed soil depth on the plant growth

The effect of mixed soil depth on the plant growing is shown in figure (6). A clay soil sample was mixed with sand at a ratio of 20 % clay and 80 % sand by weight and put in pots at different depths. These pots were used in order to indicate the effect of mixed clay soil depth

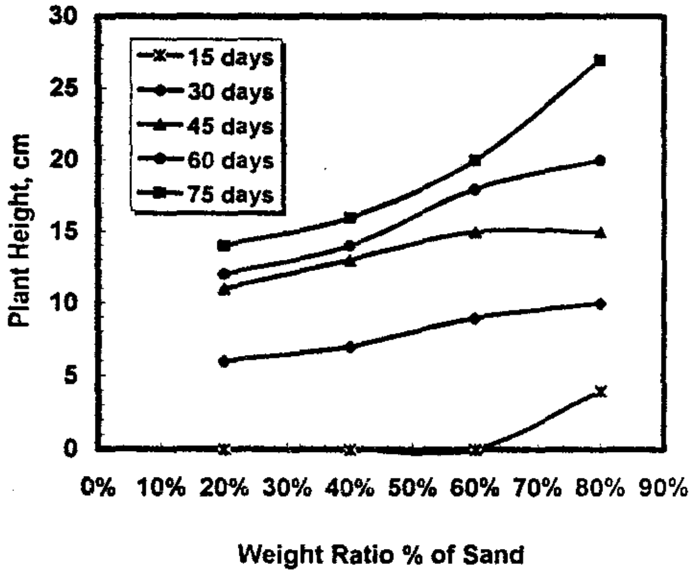

Fig. 5 Effect of weight percent of sand on wheat growth in the case of clay soil (the residual clay after the treatment of waste by flotation).

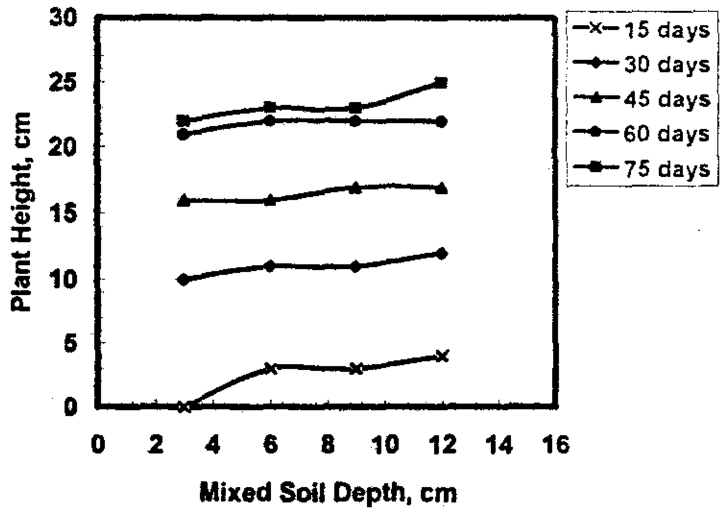

Fig. 6 Effect of mixed soil depth on wheat growth

on the plant growing rate. The results obtained from this figure indicated a slight increase in plant growing rate as a result of the increase of mixed soil depth from 3 cm to 12 cm. This may be due to the root growing of plant, i.e., when the plant root extended deeper in the soil; it needs a relative depth of fertile soil to be able to absorb the nutrient elements from it.

IV. CONCLUSIONS AND RECOMMENDATIONS

The weight percent of clay rejected as a tailing from the treatment process of the filter cake produced from El-Maghara coal washing plant was found to be about 51 % by weight. The filter cake can be used as it is, i.e., before the treatment process by flotation, in cultivation with some drawbacks, namely, the presence of high content of coal fines (about 45 %) and the medium porosity of such filter cake. Accordingly, the performance of filter cake soil will depend on the percentage of coal fines existing in it. This in turn, will lead to the reduction of nutrient elements existing in such filter cake soil. In spite of that the used clay soil is richer in nutrient elements, the rejected clay was found to be the worst among the investigated soils. This unexpected result can be attributed to the very low porosity of such clay, which leads to suffocate the roots of wheat plant by preventing the oxygen to reach to them. By mixing such clay with sand, the low porosity has been overcome and its quality was improved and became suitable for cultivation. By increasing the weight percent of sand in the mixture, the plant growth was found to increase. Also, it was found that the plant growth increases by increasing the mixed layer depth.

From the above conclusions, the reclamation of sandy soil, around El-Maghara coal mine, can be achieved by exploiting the clay tailing produced after the treatment process (flotation process) for the filter cake which produces as a waste from El-Maghara coal washing plant.

After this preliminary study, it is important to recommended that both of the treatment process for the filter cake by flotation and the reclamation process by using the filter cake and the clay tailingshould be investigated in pilot scale under the supervision of specialist in the two branches of mineral processing and land reclamation.

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الملخص العربي

استخدام طفلة غسيل فحم المغارة فى تحسين التربة الزراعية

تعتبر معالجة النفايات من الأمور الضرورية التى تخدم مجالات عديدة ، منها على سبيل المثال الصناعة والزراعة والبيئة ، وخاصة إذا تم إعادة استخدام محتويات هذه النفايات فى استخدامات مفيدة. ومن هذا المنطلق قد تم معالجة النفايات الناتجة من مصنع غسيل فحم المغارة بواسطة عملية التعويم ، وذلك لاسترجاع كمية الفحم الناعم الموجود فى هذه النفايات ، ونتج عن ذلك كميات كبيرة من الطفلة. ووجد أن أنسب استخدام لمثل هذه الكميات الهائلة من الطفلة هو محاولة استخدامها لتحسين التربة الصحراوية حول منطقة المنجم لتكون مناسبة لزراعة المحاصيل المختلفة. وفى هذا البحث اعتمد العمل التجريبى على مقارنة تربة وادى النيل مع الطفلة الناتجة بعد عملية معالجة النفايات بواسطة عملية التعويم وأيضاً مع النفايات ذاتها قبل عملية المعالجة بالتعويم. وقد اعتمد فى عملية المقارنة على زراعة نبات القمح فى التربة المختلفة والاعتماد فقط على معدل نمو نبات القمح فى المقارنة. وقد وجد من التجارب العملية المبدئية أنه من الممكن استصلاح التربة الصحراوية حول منجم فحم المغارة بخلط الطبقة السطحية من التربة الصحراوية مع الطفلة الناتجة من معالجة نفايات مصنع غسيل فحم المغارة بواسطة عملية التعويم.