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RECLAMATION OF DISTURBED TERRAIN BY USING WASTEWATER SLUDGE: CYPRUS ASBESTOS MINES

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ABSTRACT. Disturbed sites like Amiandos(asbestos) mine in Cyprus when appropriately developed and reshaped can be used for a variety of uses. If a revegetation project is to be applied, the lack of fertility of the disturbed terrain is a serious drawback. Various combinations of wastewater sludge and local soil remaining after mining works are to used in order to determine optimized conditions. Sludge which is a valuable soil enrichment resource in combination with the spoil material produced after mining activities, is believed to be effective in the reforestation and revegetation processes. As asbestos control is a complicated and lengthy process, this paper will concentrate on the enriching effect of sludge on the sterile soils of the area.
Key words: Revegetation, reclamation, disturbed terrain, sludge.

РЕКУЛТИВАЦИЯ НА НАРУШЕНИ ТЕРЕНИ С УТАЙКИ ОТ ОТПАДЪЧНИ ВОДИ: АЗБЕСТОВИ МИНИ В КИПЪР

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РЕЗЮМЕ. Нарушени терени, като площадките на азбестовите мини Амиандос в Кипър могат да се използват за различни цели, в случай че се рекултивират правилно. При извършване на залесяване, липсата на плодородност на почвата на нарушената площадка е сериозна пречка. За определяне на оптималните условия трябва да се извършат експерименти с различни комбинации от утайки от отпадъчни води и почви от района. Утайките от отпадъчните води са ценен ресурс за обогатяване на почвите и в комбинация с материалите, които остават след минната дейност се считат ефективни източник в процеса на повторно залесяване. Тъй като управлението на азбестовите отпадъци е сложен и продължителен процес, този доклад се фокусира върху ефекта на обогатяване на стерилните почви в района.

Introduction

The Cyprus asbestos mines are situated in the Troodos Mountains at a height of about 1400m asl. Asbestos occurs in the ultrabasic rocks of the Troodos massif. The ultrabasic rocks have been separately mapped as dunite, enstatite-olivinite, harsburgite-wehrlit and a peridotite-pyroxenite group. The principle minerals occurring in these rocks are olivine,enstatite and diopsidic augite.

The restoration of the Amiandos mining area started in the winter of 1995.The main target of the restoration was the stabilization of the sterile spoils and the modular reforestation of the area. The main aim of the reforestation was the restoration of the local nature to its pre-mine condition which will be harmonic with the general environment of the area. It is therefore necessary to cover the area with productive soil so as trees and bushes can grow which will stabilize the soil on the slopes and reduce exposed asbestos fibers.

Sludge as enrichment material:

The shortage of humus for fertility of a disturbed terrain is a challenge for research in terms of organic enrichment. A short field investigation has been carried out, on which various combinations of wastewater sludge from Vathia Gonia treatment unit in Cyprus together with spoil which resulted after mining works have been mixed in various proportions. Lettuce was selected in this experiment, a sensitive plant which could give quick and useful results.

The characteristics of the sludge used are shown in table1 below. Spoil characteristics are shown in table 2.

Table 1.
Characteristics of experimental sludge

N(%)	P(%)	K(%)	O.M (%)	Na (%)	B (p.p.m)	Zn (p.p.m)	Cu (p.p.m)	Cd (p.p.m)	Ni (p.p.m)	Pb (p.p.m)	Cr (p.p.m)	FE (p.p.m)	MN (p.p.m)
3.47	2.0	0.26	67.0	0.35	67	1196	218	3.8	35	67	161	13213	187

It was decided to use various combinations of sludge and spoil from the site in order to create a productive cover material. All variants used together with their proportions in percentages by weight are shown in table 3.

The field experiment was carried out in experimental pots holding a 2kg total soil and sludge together, in a four-fold repetition.

Initially a close observation of the spoil material-clay (table 2) is necessary and the comments are listed below.

Table 2 spoil composition

Spoil characteristics

N	Parameters	Clay
1	Abs.dry matter %	63,03
2	Ashes %	77,19
3	Ammonium N %	0,003
4	Total N %	0,007
5	Total P2O5 %	0.007
6	Total K2O %	0,05
7	Na %	0,18
8	Mg %	0
9	Ca %	0,051
10	Al %	46
11	Fe %	1
12	Zn mg/kg dry matter	48
13	Cu -"-	10
14	Pb -"-	22
15	Ni -"-	8
16	Co -"-	3
17	Cr -"-	30
18	Mn -"-	503
19	Cd -"-	traces
20	pH	8,3

- Ph of clay is 8.3 which means that alkalinity condition prevail and this decreases the concentration of toxic ions in the soil solution and helps the release of more essential nutrients to become available.
- A phosphorous deficiency is evident in the clay material (0.7 ports per million), as well as low levels of Nitrogen and nutrients necessary for plant growth.
- Care should be taken when using only clay, as clay mineralogy influences the degree of compaction that may result after the use of heavy compaction equipment which may be used in the stage of mining and reshaping. There is evidence that compaction may limit plant growth by reducing water infiltration and nutrient release. Smaller particles expose a larger surface area per unit volume to forces of weathering than coarse fragments. This results in a more rapid release of chemicals during the weathering process.

Results and Discussion

Interesting results were obtained as shown in figure 1 below. For each sample the growth pattern is demonstrated. The total growth is found if the initial growth is subtracted from the final growth.

The highest growth pattern appears in sample no.7 where a 20 percent sludge was used. Satisfactory growth is shown in all samples where sludge was used. Good results are shown in almost all sludge proportions, with the poor results evident at the no sludge sample no. 1.

Table 3.
Proportions of mixing for spoil and sludge

Sample No.	1	2	3	4	5	6	7	8	9	10
Spoil Content (%)	100	0	100 %	95	90	85	80	75	50	25
Sludge Content(%)	0	100	Spoil irrigate with fertilizer	5	10	15	20	25	50	75

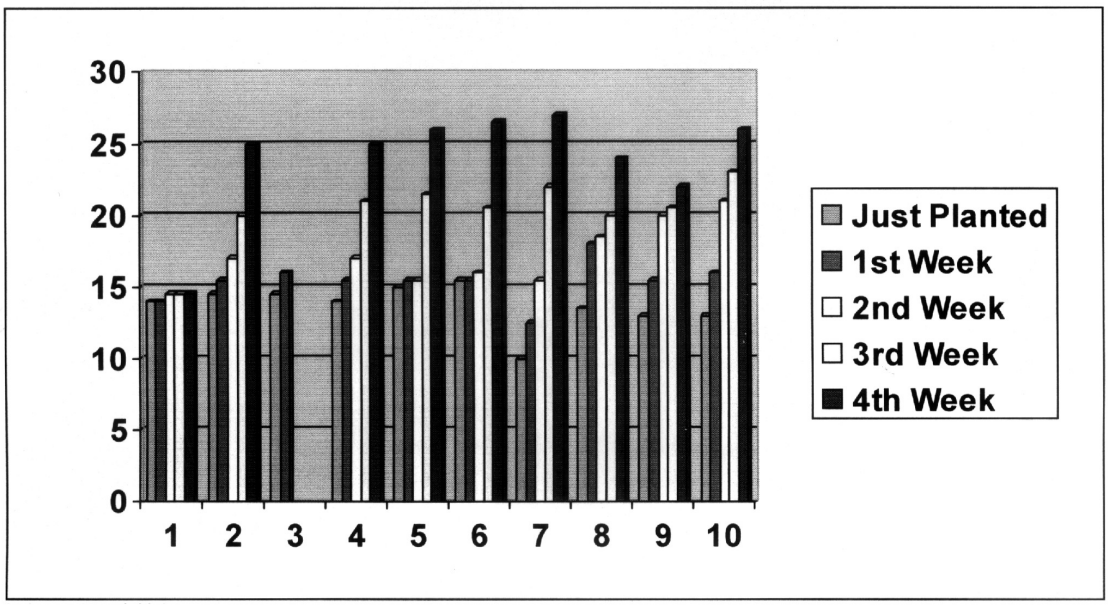

Fig. 1. Speciment number against growth in cm

Conclusions

Application of sludge for the enrichment of disturbed sites is considered a feasible sludge disposal method. The experiment performed indicates that the received soil substrates are good medium for the development of plants and can be recommended. Optimal results are demonstrated around the 20 percent sludge quantity.

As our purpose is soil enrichment, an economic analysis will determine the optimal sludge proportions for the selected plants. Groundwater pollution as well as other ecological risk factors as applied and in accordance to EU directives should be considered.

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