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Amelioration of Sugar Mill Effluent Polluted Soil and its Effect of Greengram (*Vigna radiata* L.)

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Abstract: Sugar mills plays a major role in polluting the water bodies and land by discharging a large amount of wastewater as effluent. The sugar mill effluents are having higher amount of suspended solids, dissolved solids, BOD, COD, chloride sulphate, nitrates, calcium and magnesium. The continuous use of these effluents harmfully affect the crops when used for irrigation. As a result, a higher amount of various elements get deposited in the soil and make them polluted. Since this polluted soil reduces both the crop production as well as the soil properties it was decided to give some bioremediation measures by growing the tree species in polluted soil. The tree species like *Polyalthia longifolia, Pithocolobium dulce, Moringa olefera, Tamarindus indicus, Samanea saman, Azadirachta indica* and *Acacia nilotica* were grown in the polluted soil upto 120 days. The treatment in which all tree species grown in one pot showed a remarkable reduction of pollutants. The bioremediated soil showed a good germination of green gram seeds. In another experiment, the polluted soil were mixed with some organic amendments like coir waste, vermicompost, *Rhizobium* and cow dung to improve the soil fertility and their efficacy was tested by growing green gram plant in that soil. Among the amendments, the vermicompost mixed polluted soil showed good morphological and yield parameters.

Key words: Bioremediation · Effluent · Cultivation · Amendments · Germination studies · Yield

Nomenclature and Abbreviations:

BOD-	Biological Oxygen Demand	COD-	Chemical Oxygen Demand
DAS-	Days After Sowing	G%-	Germination Percentage
K-	Kemp's constant	mM/hos-	Micro moles hours
ppm-	Parts per million		

INTRODUCTION

Environment is the sum of all social, economical, biological, physical or chemical factors which constitute the surroundings of men, the creators and moulders of the environment. All types of revolutions (green revolution, blue revolution, white revolution and industrial revolution) fulfill the needs of growing population on one side and on other side it cause all kinds of pollution which alter they physico- chemical and biological characteristics of the environment. Water is the universal solvent and it is one of the most important natural resources. In recent years, much of the water bodies has become polluted by sewage, industrial wastes and wide array of synthetic chemicals [1]. Advances in Science and technology and the industrial revolution have increasing enabled humans for plot resources. Industrialization forms one of the cause for the economical development of a nation. During the production, industries generate useless byproducts and waste materials with 1 to 10 % of the quantity of parent chemicals. Soil is a dynamic, living matrix that is an essential part of the terrestrial ecosystem. It is a critical resource not only for agricultural production and food security, but also towards maintenance of most life process. The function of soil biota are central to decomposition processes and nutrient cycling. The effluent from various industries like chemical, sago, sugar mill, textile, dairy, tannery industries are the major cause of soil pollution. These industries produce large amount

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of waste water as effluent. All types of effluents and most of the byproducts from any kind of industry create most serious pollution to the water bodies and soil properties.

India being one of the largest producer of sugar in the world and the sugar mills are potentially producing about 182 lakh. tonnes of sugar per year [2]. The sugar mill effluent is mainly discharged from floor, waste water and condensate water formed by leakage. The disposal of waste water is one of the main problem of today and have to be faced in future with its increased adverse effects. Most of the sugar mills are discharging their effluent to the environment without any treatment. Sugar industry effluent constitute number of physico-chemical elements of suspended and dissolved solids with the high amount of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), chlorides, sulphate, nitrates, calcium and magnesium. In addition to that, some traceable amount of heavy metals such as zinc, copper and lead are usually present in the effluent [3]. The presence of these chemicals in large quantities in the effluent not only affect plant growth but also collapses the soil properties when used for irrigation. The polluted soil becomes unsuitable for further cultivation. So, it was decided to give some bioremedial treatments to sugar mill effluent polluted soil.

Bioremediation is the use of biological agents such as bacteria, fungi and plants to remove or degrade the pollutants from the contaminated soil. This technology has appeared to reduce the enormous costs and environmental disturbance that are associated with current clean up method. It is necessary to conduct experiments on the impact of these polluted soil on agricultural crops before they are used for crop cultivation [4]. Phytoremediation is an emerging technology which uses plants and their associated microbes to remove, degrade, the polluted medium. It has been successfully employed for remediation of different kind of contaminants. Tree species play a major role in reclamation of pollutants. Growing of tree seedlings is one of the most promising and potentially effective techniques for the removal of pollutants [5]. The toxic compounds are trapped into the trunks of such tree species which will remain for a longer time and will not come to the food chain as well. It is an affordable technology that is most useful when the contaminates are with the root zone of plants.

Amendments act as vital remediational measures. Primarily the amendment microorganisms are found to be very effective to degrade the environmental contaminants in to less toxic forms. There are number of previous literature available regarding the bioremediation of industrial polluted soil [4, 6-14]. So, the present work deals with bioremediation of sugar mill polluted soil by growing tree species and amendments mixed polluted soil and its response on *Vigna radiata*.

MATERIAL AND METHODS

Sugar Mill Polluted Soil: The sugar mill effluent polluted soil sample was collected in polythene bags from N.P.K.R. Ramasamy sugar mill Ltd., Thalainayar. Nagapattinam district of Tamil Nadu, India. The polluted soil was analysed for its various physico-chemical parameters. The seeds of greengram were collected from Tamil Nadu Rice Research Station, Aduthurai, India.

Remediation of Polluted Soil (Tree Species): The seedlings of various tree species like *Polyalthia longifolia*, *Pithocolobium dulce, Moringa olefera, Tamarindus indicus, Samanea saman, Azadirachta indica* and *Acacia nilotica* collected from Forest Research Station, Coimbatore were used for this bioremediation study.

Pots were filled with 5 kg of sugar mill effluent polluted soil. The seeds of tree species were sown in pots separately and also in combination *viz.,* each tree species grown in separate pots to know the efficacy of the species in removing pollutants. All species were allowed to grow in polluted soil upto 120 days. The soil samples were collected from the pot at 120 day and they were analysed to know their properties.

Amendments: Amendments like vermicompost, cow dung, coir pith, *Rhizobium* were collected from Faculty of Agriculture, Annamalai University, Tamil Nadu, India. Polluted soil and amendments (2:1 ratio) were mixed and used to study the germination, growth and yield of greengram.

Germination Experiments: The bioremediated soils were analysed and they were used for germination studies of greengram (*Vigna radiata* L.). The morphological parameters like germination percentage, seedling length and seedling dry weight, vigour index, tolerance index and percentage of phytotoxicity were calculated on 15^{th} day old seedlings.

Morphological Parameters

Germination Percentage (G%): The number of seeds germinated in each treatment was counted on 7^{th} DAS and the germination percentage was calculated by using the following formula.

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

Shoot, Root Length and Fresh Dry Weights: Five seedlings were taken from each treatment and their shoot and root length (cm/seedling) were measured by using a scale and these values were recorded. Five seedlings were collected from each treatments and their fresh weight (g/seedling) were measured with the help of an electrical single pan balance. Their dry weight (g/seedling) were taken after keeping them in a hot air oven at 80°C for 24 hrs. by using an electrical single pan balance.

Total Leaf Area (Cm^2): The leaf area was calculated by measuring the length and breadth of the leaf as described by [15].

$$\text{Leaf area } (cm^2) = K \times \text{length} \times \text{breadth}$$

Where, K= Kemp's constant (for dicot leaves) = 0.66.

Yield (kg/m^2): Five plants samples were taken from each treatment at the time of harvest for the observation of the yield parameters such as number of pods per plant, number of seeds per pod, 100 seed weight and yield of plant (kg/m^2).

RESULTS AND DISCUSSION

Physico-chemical analyses of sugar mill effluent polluted soil and bioremediated soil using tree species are shown in Table 1. It showed a remarkable variation in soil properties when compared to polluted soil. The polluted soil were found with excess and less amount of micro and macronutrients which will reduce the plant growth. At the same time, the bioremediated soil analysis reveals that it has a reduced amount of pollutants. The removal of elements from polluted soil may be due to hyperaccumulation of the contaminants by tree species and they translocate it from the root to the shoots and leaves. This process can be compared to the solar driven pumps which can extract and concentrate certain elements from their environment [16]. Pollutant accumulating plants are utilized to transport and concentrate contaminants from the soil to the shoot above. [17,18]. The industrial effluent polluted soils can be treated by growing small suitable native plant species for reducing the polluted soil toxicity. Plants growing on such polluted soil absorb nourishments from them and entry of pollutants to the plant system during the process of absorption may not be ruled out. This may be theoretical phenomena assumed that the lowering of the pollution level of the soil. Species tolerant to the stress has been proposed as the indicators and bio accumulators of the pollutants [5]. The bioremediated soil may be used for germination studies with greengram seeds. The plant (greengram) growth is increased in bioremediated soil when compared with polluted soil. Among them, the good germination was observed in all tree species grown in one pot polluted soil (Table 2).

The physico-chemical analysis of sugar mill effluent polluted soil revealed that it contains the higher amount of minerals and toxic pollutants and than soil organic matter (Table 3). These polluted soil is unfit for cultivation. So it is decided to give certain soil amendments like cow dung, coir waste, *Rhizobium* and vermicompost by mixing with polluted soil to improve the soil fertility. The amendment mixed soil analysis reveals that it contained the required amount of organic matters and neutralize the minerals and nutrients. The greengram seedlings grow vigorously in the amendments mixed with polluted soil. Among the amendments, the soil mixed

Table 1: Physico-chemical properties of polluted soil and bioremediated soil

		Soil properties								
S.No	Name of the organisms used for bioremediation	pH	EC (mM hos)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Mn (ppm)
1.	Polluted soil (Control)	6.0	0.43	92	50	450	0.75	7.28	21.28	15.64
2.	All tree plants in one pot	6.6	0.26	63	19	60	0.52	0.93	4.76	3.77
3.	Polyalthia longifolia	6.5	0.36	67	34	43	0.59	2.00	17.94	3.00
4.	Pithocolobium dulce	6.3	0.20	69	48	48	0.61	2.00	5.11	2.46
5.	Moringa olefera	6.2	0.36	56	17	98	070	1.81	12.19	2.28
6.	Tamarindus indicus	6.8	0.45	77	16	113	0.62	0.90	11.50	4.33
7.	Acacia nilotica	6.5	0.38	64	19	60	0.69	7.03	13.54	3.22
8.	Samanea saman	6.8	0.47	65	10	85	0.59	7.00	17.41	2.23
9.	Azadirachta indica	6.8	0.11	74	34	38	0.63	4.52	6.37	2.5

N-Nitrogen; P-Phosphorus; K-Potassium

Table 2: Germination studies of greengram (*Vigna radiata* (L.) Wilzcek grown in the bioremediated soil

Sl.No	Name of the organisms used for biorediation	Germination percentage	Seedling growth (cm/seedling)	Seedling dry weight (g/seedling)	Vigour index	Tolerance index	Percentage of phytotoxicity
1.	Polluted soil (Control)	55 ± 2.75	12.5 ± 0.625	0.55 ± 0.0275	687.5 ± 34.37	-	-
2.	All tree plants in one pot	90 ± 4.50	29.6 ± 1.480	0.978 ± 0.0489	2664 ± 133.20	1.2035 ± 0.060	0.2045 ± 0.010
3.	Polyalthia longifolia	88 ± 4.40	27.2 ± 1.360	0.826 ± 0.0413	2393 ± 119.65	1.0353 ± 0.051	0.100 ± 0.005
4.	Pithocolobium dulce	88 ± 4.30	28.8 ± 1.440	0.768 ± 0.0384	2534 ± 126.70	1.2035 ± 0.060	0.2035 ± 0.010
5.	Moringa olefera	86 ± 4.30	25.0 ± 1.250	0.628 ± 0.0314	2150 ± 107.50	1.1327 ± 0.056	0.1327 ± 0.006
6.	Tamarindus indicus	86 ± 4.30	26.8 ± 1.340	0.820 ± 0.0410	2304 ± 115.20	1.0884 ± 0.054	0.6880 ± 0.034
7.	Acacia nilotica	88 ± 4.40	22.6 ± 1.130	0.601 ± 0.03005	1988 ± 99.20	1.0088 ± 0.050	0.8938 ± 0.0446
8.	Samanea saman	80 ± 4.00	24.8 ± 1.240	0.725 ± 0.03625	1984 ± 99.20	0.9911 ± 0.0490	0.8788 ± 0.0439
9.	Azadirachta indica	86 ± 4.30	28.2 ± 1.410	0.848 ± 0.0424	2425 ± 121.25	1.1858 ± 0.059	0.8592 ± 0.0429

± Standard deviation

Table 3: Physico-chemical properties of amendment mixed polluted soil

Amendments	PH	EC (mM/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Copper (kg/ha)	Zinc (ppm)	Iron (ppm)	Mn (ppm)
Polluted soil (control)	4.5	0.5	0.92	50	150	0.65	2.28	13.54	3.00
Polluted soil + coir waste	6.5	0.34	94	40	82	0.55	1.70	6.94	2.59
Polluted soil + biofertilizer (*Rhizobium*)	6.9	0.30	99	29	73	0.52	1.32	5.80	2.33
Polluted soil + cow dung	7.0	0.33	84	42	89	0.59	1.85	7.80	2.70

Table 4: Growth and yield of greengram (L.) grown under sugar mill effluent polluted soil mixed with various soil amendments

Various soil amendments	Parameters studied: Shoot length (cm/plant)	Root length area (cm^2/plant)	Total leaf area (cm^2/plant)	Fresh weight (g/plant)	Dry weight (g/plant)	Number of fruits/plant	Number of seeds/fruits	Yield (g/m^2)
Polluted soil (control)	17.6±0.880	10.4±0.520	238.2±11.910	1.540±0.077	0.454±0.022	8.5±0.425	65.8±3.290	590 (29.5)
Vermicompost	34.6±1.725	21.0±1.050	362.92±18.12	6.785±0.33	3.168±0.15	14.2±0.71	78.5±3.92	612±30.60
Coir waste	28.5±1.425	18.6±0.930	352.08±17.42	5.286±0.26	3.078±0.15	13.0±0.65	77.8±3.89	608±30.40
Biofertilizer	26.5±1.320	19.0±0.950	348.51±17.42	5.085±0.25	2.768±0.13	13.2±0.66	77.2±3.86	592±29.60
Cow dung	23.0±1.150	20.0±1.000	288.21±14.4	4.780±0.23	2.570±0.12	12.2±0.61	73.5±36.7	585±29.25

± Standard deviation

with vermicompost get higher growth performance of greengram seedlings when compared with other amendments (Table 4) certain earlier findings are in conformity with our results. It was reported that the application of vermicompost increased the value of plant height, leaf area, dry matter content and yield. This may be due to the higher rate of multiplication of soil microbes leading to improvement in physical properties of soil [19]. Vermicompost has been reported to contain large number of nitrogen fixing phosphate, solubilizing and other beneficial microorganisms which have favourable effect on growth and yield of plant. At the same time, the application of soil amendments improved the soil fertility and plant growth.

CONCLUSION

The tree species like *Polyalthia longifolia, Pithocolobium dulce, Moringa olefera, Tamarindus indicus, Acacia nilotica, Samanea saman* and *Azadirachta indica* were allowed to grow in the polluted soil upto 120 days. Among bioremediation treatments, the polluted soil treated with all tree species showed the high degree of pollutants reduction than the soil treated with a single tree species. The bioremediated soil showed a better performance in germination studies than that of polluted soil. Among the soil amendments, vermicompost showed a better performance of reclamation of polluted soil and also increased the germination, growth and yield of crop plant when compared to other amendments. It is also advisable to farmers to give remediation treatment to polluted soil before sowing, for getting good yield in agriculture.

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