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Impact of vegetable oil mill effluents on soil characteristic in Bundi district, Rajasthan, India

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Abstract
Industries play a major role in polluting the water bodies and soil by discharging a large amount of untreated industrial wastewater as effluent which generally have high amount of suspended solids, dissolved solids, BOD, COD, chloride, sulphate, nitrates, calcium and magnesium. The continuous use of these effluents for irrigation affects the soil properties as well as crops. In the present study, physico-chemical parameters of soybean and mustard oil mill effluent and its effect on soil properties was determined with an objective to find out the concentration of vegetable oil mill effluents that can be used for irrigation. After treatment of the effluents pH, total suspended solids and COD is brought down to permissible limit for irrigation. The change in soil macro and micronutrients level is manageable nearer to reference values of these nutrients for irrigation purpose only at very low concentrations. Thus soybean and mustard oil mill effluent can be used at with irrigation water in very low concentrations but the contribution of OME in irrigation in agriculture on large scale must be evaluated for economic viability.

Keywords: Vegetable oil mill effluent, Physico-chemical characteristcs, Soil

1. Introduction

Though industrialization contributes economic development of a country but it may pollute water and soil with the by- products and effluents when discharges without proper treatment. The industrial effluents contain various organic and inorganic materials as well as toxic trace elements. With the rapid growth of industries in the country, pollution of natural water by industrial waste water has increased tremendously thus deteriorating the water quality [1]. Improper management of waste products and their disposal in agricultural fields has resulted in the lower chemical and biological soil quality index and relative soil quality index [2]. Data presents only 60% of the total waste water generated by industries is treated before discharging [3] and rest discharged untreated into nearby soil or water bodies. Discharge of untreated effluent into water body resulting in increase or decrease of water pH causes increase of temperature, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), heavy metals and toxic chemicals.

Vegetable oil mill effluent varies both in quantity and characteristic depends largely on the type of oil processed and on the process implemented thus from one oil industry to another. In edible oil industry effluent mainly comes after steps involved in refining *i.e.* the degumming, de-acidification, neutralization, and deodorization [4].

Indian agriculture accounts for 90% water use due to fast track ground water depletion and poor irrigation systems [5]. There is a great demand for water for irrigation while gallons of effluents are let out into nearby water sources untreated. The increasing demand for water and dwindling supply has made the treatment and reuse of industrial effluents an attractive option. Vegetable oil refinery effluent is nontoxic and considered as a good source of organic nutrients [6]. There are few studies which state that oil refining wastewater is easily amenable to chemical and biological treatment [7] thus there is possibility to use it for irrigation.

2. Material and Methods

The study was conducted in Bundi district of Rajasthan, where two vegetable oil mills; one is mustard oil mill in Ramganjbalaji and another soybean oil mill in Silor Road are working for last 20-30 years. As claimed by administration of the mills, the effluent produced by these oil mills are transported to other cities where the effluents are treated further to make it suitable for reuse. In Bundi district 49.54% land area is under agriculture but only 21% of the total land area of district is covered under irrigation. In low rain areas soybean contribute to 5% area under cultivation in kharif crop whereas mustard accounts for 30% area under cultivation in rabi crop. Soybean is the major crop in the study area which is grown in 83805 ha land area with annual production of 102683 MT and the productivity of soybean in 1230 Kg/ha according to District Agriculture Department in 2014-15. Thus present study was conducted to work out the effect of different concentrations of soybean and mustard oil mill effluent on soil characteristics and to identify the concentration of the effluent that is has nil or least negative impact on plants and which can be used as alternative of irrigation water.

The effluent from Soybean and Mustard oil mill located in the study area was collected in pre-cleaned, acid washed, plastic bottles which was later stored in a refrigerator below 4º until used to avoid changes in their physico-chemical properties. Untreated and treated effluent samples were tested for pH, total dissolved solids, total suspended solids, oil and greases and COD. Different concentrations ranging from 0% effluent conc. (control soil without effluent), 10% OME, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% (pure effluent) were prepared. While preparing different concentrations of OME for experiment treated OME was used. Soil sample without effluent (0% OME) is used as control whereas undiluted OME is used as 100% OME. Different effluent concentrations are poured in two sets of soil samples (one set for Soybean OME and other for Mustard OME) in petri dishes 2-3 times. Soil samples treated with different OME concentrations were subjected to test for parameters used for agricultural purpose *i.e.* pH, electro-conductivity, organic carbon, nitrogen, phosphorus, potassium, zinc, iron, copper, manganese were determined using standard methods [8].

Data collected was subjected to statistical analysis using Pearson correlation coefficient '*r*' to test the intensity of relationship between OME concentration and physico-chemical parameters of soil. Student's'*t*' test was conducted to test the significance of '*r*'.

3. Results and discussion

The untreated (crude) effluent samples shows highly acidic condition with pH range from 2.0-4.0 for soybean OME and 1.5-3.0 for mustard OME whereas treated OME shows pH range of 6.85-6.95 for both the OME. Untreated OME have very high total dissolved and total suspended solids which are reduced to 120 and 140 after treatment for soybean and mustard OME respectively. Untreated OME have very high range of Oil and greases and COD which are reduced after treatment to 100ppm and 90ppm for Oil and greases and COD to 110ppm and 98ppm for soybean and mustard OME respectively. Similarly, the effluent had a very high TDS and TSS, which was in agreement with the previous studies on vegetable oil mill effluents [9].

Experimental set with 100% OME shows decrease in pH, OC, nitrogen, phosphorus, potassium and micronutrients; iron, copper and manganese. EC shows decrease with soybean OME but almost no change with mustard OME. Zn shows no change in soybean OME but very little change in mustard OME.

Table 1: Physico-chemical characteristic of crude and treated oil mill effluent

S.N.	Parameters	Permissible limits for agriculture	Untreated Soybean oil mill effluent	Treated Soybean oil mill effluent	Untreated Mustard oil mill effluent	Treated Mustard oil mill effluent
1	pH	5.5-9.0	2-4	6.95	1.5-3	6.85
2	Total dissolved solids	0-2000	7550	3000	6080	3010
3	Total suspended solids mg/L	200 mg/L	1350	120	2020	140
4	Total solids	-	9900	3210	9000	3050
5	Oil & greases (ppm)	10 mg/L	525	100	400	90
6	COD (ppm)	250 mg/L	4550	110	4100	98

Table 2: Physico-chemical characteristics of control soil (without effluent), 100% soybean oil mill effluent and 100% mustard oil mill effluent.

S.N.	Parameters	Reference values for agriculture	Control (soil without effluent)	Treated soybean oil mill effluent (100%OME)	Treated mustard oil mill effluent (100%OME)
1	pH	7-8.5	7.50	6.95	6.85
2	EC (dsm-1)	1.5	0.33	0.30	0.34
3	Organic Carbon (%)	0.5-0.75	0.44	0.37	0.36
4	Nitrogen (Kg/ha)	280-560	344	318	310
5	Phosphorus (Kg/ha)	23-56	48	42	40
6	Potassium (Kg/ha)	144-336	425	417	388
7	Zinc (ppm)	>0.6	3.62	3.62	3.52
8	Iron (ppm)	>4.5	20.94	19.27	15.07
9	Copper (ppm)	>0.2	2.17	2.15	1.62
10	Manganese (ppm)	>2	58.90	44.14	31.59

With increasing concentrations of effluent from 0% to 100%, pH decreases in both the experimental sets but it is more prevalent in mustard OME. After 70% it falls below the lower limit of reference value (pH 7) with both the OME. Electro-conductivity shows no change upto 70% mustard OME then shows slight increase whereas with soybean OME electro-conductivity decreases after 30% OME. Organic carbon (OC) shows same trend in both cases as it shows the decreasing trend with increasing OME concentrations. With 10% mustard OME and 0% soybean OME the OC is same as control beyond this concentration OC shows decreasing trend. Decrease in nitrogen content of soil is more prevalent in mustard OME than soybean OME after 30% OME. Upto 20% mustard OME the decrease in nitrogen is not remarkable whereas with soybean OME not change is seen upto 10% soybean OME. In case of phosphorus, after 20% soybean OME there is continuous decrease with increasing concentration but in case of mustard OME upto 50% OME concentration the decrease is not very remarkable and after 50% there is remarkable decrease to 40kg/ha. There is gradual decrease in Potassium in experimental set with soybean OME after 10% OME but with mustard OME the decrease is very prevalent even after 0% OME from 425 to 388kg/ha.

Zn remains unaffected with increasing concentration of soybean OME whereas with mustard OME, it remains unchanged upto 30% concentration after that it gradually decreases. Decrease in Iron content is not very remarkable with soybean OME but with mustard OME the decrease is very prominent from 20.94 in 0% OME to 15.04 kg/ha in 100% OME. Almost same trend is followed in case of Copper as the decrease in copper content is not very prevalent with Soybean OME (starts decreasing trend after 50% OME Conc.) but it is remarkable in experimental set with mustard OME (2.17kg/ha in 0% OME to 1.62 kg/ha in 100% OME). Results show that Manganese content decreases with both the OME. In case of soybean OME there is a sudden fall of Mn at 60% OME whereas with mustard OME sudden decrease in Mn content occurs at 50% OME.

Statistical analysis shows linear relationship between OME concentration and nutritional status of the soil. Very high -ve value of ‘*r*’ in each case shows a strong negative correlation between the OME concentrations and macronutrients as well as micronutrients of the soil. The value of r^2 is very high (range 0.76 to 0.97 except Zn for soybean OME and 0.6 to 0.96 for Mustard OME) which shows that variation in physic-chemical characteristic of soil is negatively influenced by change in OME concentration. At 5% probability level the observed value of ‘*t*’ in every case is higher than the critical value (2.262) showing that there is less than 5% chance of error.

The results show that some of physico-chemical parameters of the effluent were found to exceed the reference values. The pH was relatively low due to the use of phosphoric acid (H_3PO_4) during refining process. The refining process of vegetable oils generates acidic wastewater (pH 1–1.5), COD (10–30 g O_2/L), suspended solids (7–12 g/L) and fats (2–4 g/L) [10]. The neutralization step, in particular, produces Na salts of free fatty acids (‘soap stocks’) whose splitting through the use of H_2SO_4 generates highly acidic and oily wastewater. The presence of high level of TSS and TDS may be due to the insoluble organic and inorganic present in the effluent [9].

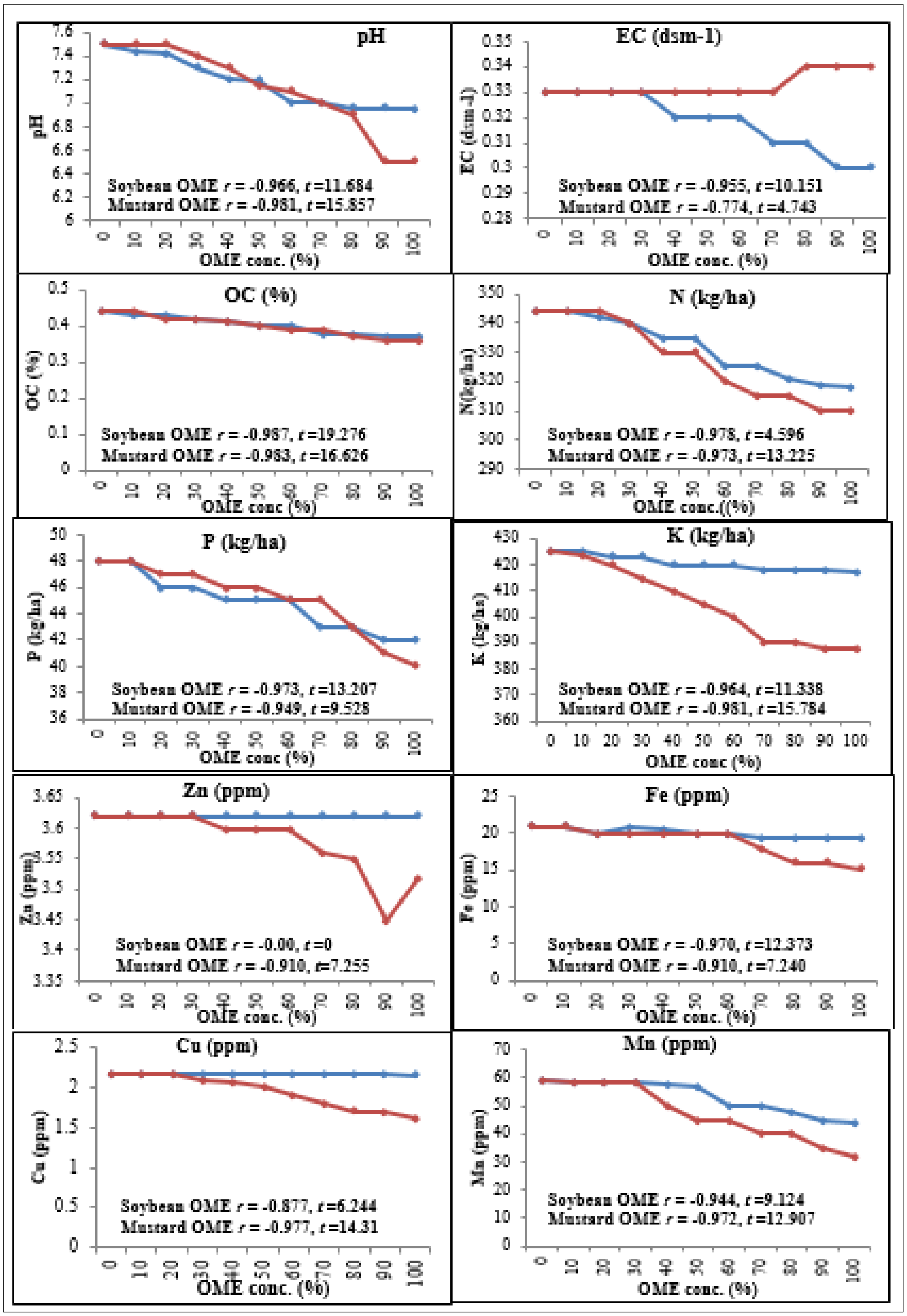

Fig 1: Graph showing effect of different concentrations of soybean and mustard OME on various parameters of soil characteristics.

Soybean OME Mustard OME

The refined soybean oil wastewater has a high concentration of chemical oxygen demand (COD) and contains large amounts of Na salts from free fatty acids soap stocks, oil, grease, sulphates, and phosphates [11]. The COD value of the untreated effluent was 4550mg/L and 4100mg/L for soybean and mustard OME respectively, while the recommended level set by BIS is 250 mg/L; the measured COD indicates the high organic load similarly other factors exceeded the permissible limits. These results are in agreement with the previous studies [11]. Increased amount of COD may be due to high amount of organic compounds which are not affected by the bacterial decomposition. The increase in EC may be due to total oxidation and decomposition of organic matter into simple nutrients). Oil refining units produce wastewaters that contain mostly biodegradable organic substances [12]. On the contrary an effluent from the vegetable oil industry usually has its BOD/COD ratio around 0.2 which could cause destruction of micro-organisms useful for the biodegradation [13]. In this way the harmful effluent discarded in its raw form causes substantial impacts on the environment.

India is an agriculture based country and a major user of water resource for irrigation [14]. But there is a great demand for water for irrigation while huge amount of waste water generated from agro-products based industries are discharged on land or into the water bodies. As a result toxic metals can be transferred and get accumulated into plant tissues from soil. These metals have damaging effects on plants themselves and may in turn become a health problem to man and animals and it is major concern of existing environment. Refined Soybean oil wastewater is usually treated by a combination of pre-treatments to dislodge the oil and grease and more than 90% of the COD and oil content is removed by biological and advanced treatments [12, 15]. This may be the reason that vegetable oil mill effluents are considered safe. In many cases use of effluents for irrigation after dilution is beneficial for plant growth and yield. This is the way that inorganic and organic contents of effluents can be used as a substitute of chemical fertilizers for enhancing the plant growth [16]. Some effluents at certain dilution are found to be beneficial for irrigation purposes [17]. There appeared to be no adverse impact on soil characteristics, but continued irrigation with waste water might increase sodicity and salinity that could deteriorate soil and pose a threat to future crop production [18]. Irrigation with the effluents may affect the soil pH, nutrient content, soil ionic balance and availability of essential minerals to the plants and various physico-chemical properties of the soil which are vital for plant growth. The pH is an essential parameter for soil and water to be used for agriculture. If the acidic OME is used for irrigation over a large area for longer time, the soil becomes acidic resulting in poor crop growth, output and yield.

Use of waste water in agriculture is gaining importance in recent years because of its value as a potential irrigant and nutrient donor. This concept makes it possible to conserve the limited water resources for crop production and also prevent pollution of land and water bodies as soil is a very good sink. Application of wastewater to agricultural land may promote the growth of crops and conserve water as well as nutrient. However, indiscriminate use of industrial effluents may cause pollution problem in the long run when they are not properly handled before and after their application to land [19]. The agricultural production in many countries is heavily affected by the reckless discharge of these effluents to the water bodies or land near industrial establishments. Therefore, screening of crops for their sensitivity / tolerance variance to different types of effluent is the need of the day. After proper dilution and systematic application, the treated effluent cause no harm to soil as it has essential nutrients along with exuberant load of microbial population and enzyme activity.

Conclusion

The results of the study contradicts the reports that soya oil refinery effluent is nontoxic and considered as a good source of organic nutrients and land application of soya oil refinery effluent can be a suitable waste management [7]. Results show that though there is change in physico-chemical properties and macro as well as micronutrient status of soil when OME is mixed in the native soil but it is manageable upto a certain OME concentration. Usually recycle, recovery and reuse of water are adopted with aim to achieve the target of zero discharge for ecological and economical gains [20]. In this context it can be concluded that soybean and mustard oil mill effluent can be used with irrigation water in very low concentrations but their contribution in irrigation on large scale in agriculture is first evaluated for economic viability of use of vegetable oil mill effluent.

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