Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 6[3] February 2017: 23-27

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Efficacy of Distillery Spent Wash as an Economical Soil Amendment for Sodic Soils

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ABSTRACT
Distillery spent wash are commonly disposed in open drains that causes several problems including polluting aquatic system as well as deteriorating soil and water quality. Therefore, to convert this pollutant into an economical source of soil amendment, raw distillery spent wash (RDSW) was tested for its efficacy in reclaiming sodic soil. The treatment of RDSW in sodic soil showed that it affects the physico-chemical properties of the soil in such a way that it reduces especially exchangeable sodium percentage by 55.96 %, electrical conductivity by 16.36 %, exchangeable sodium by 9.61 % and pH of the soil by 17.24% over four weeks of the treatment, reflecting its potential as an efficient eco-friendly soil amendment for sodic soil. The investigation generated details on the effectiveness of the distillery spent wash to be used as a source of nutrient and soil amendment for sodic soils.
Keywords: *Distillery spent wash, exchangeable sodium percentage, sodic soils.*

Received 11.12.2016 Revised 30.12.2016 Accepted 09.01. 2017

INTRODUCTION

The extent of land degradation due to salinity and sodicity is estimated at about 955 million ha worldwide [1], covering about 7% of the world's total arable land. According to FAO/UNESCO Soil Map of the world, the total area of sodic soils including both arable and uncultivated land is 434 million ha [2]. In India, about 2.5 million ha have been affected solely by sodicity [3]. It justifies the need of immediate attention to adopt efficient, economical and environmentally acceptable reclamation practices. Sodic soils are usually characterized by the predominance of sodium (Na^+) and usually associated with high levels of both pH soluble salts that can create profound negative impact on chemical and physical properties of soils and plant growth. The basic principle of sodic soil reclamation is to provide a source of calcium (Ca^{2+}) to replace excess sodium (Na^+) from the cation exchange sites. Under chemical amelioration technique, several amendments such as green manure, gypsum, farmyard manure, goat manure, compost etc. can be used to either change insoluble soil calcium to soluble form or supply calcium directly, which replaces the absorbed sodium from sodic soils [4]. Distillery spent wash is usually of high acidity and contains fair amount of Ca and Mg. Therefore, distillery spent wash can be used as an organic amendment in improving physical and chemical properties of soil [3]. The objective of the study is to test the efficiency of distillery spent wash as an effective soil amendment of sodic soil.

MATERIALS AND METHODS

Collection of spent wash

The spent wash was collected in polythene containers from M/s. Chemplast Sanmar (P) Ltd., located at Panruti, Cuddalore district, Tamil Nadu. The containers were properly sealed and stored at 4°C for further analysis.

Preservation of spent wash

Samples for the estimation of microbial dynamics were collected in 250 ml sterilized bottles. The sampling bottles were closed with ground glass stoppers having an overlapping rim. The stoppers were relaxed by intervening strip of papers to prevent breakage during sterilization. The bottles were protected by covering with aluminum foil and sterilized in an autoclave at 20 psi for 15 minutes. The bottles were opened only at the time of sampling.

The samples for the analysis of dissolved oxygen content were added with one ml of manganese sulphate and one ml of potassium iodide solution as given in the procedure for the estimation of dissolved oxygen. Samples for the determination of Biological Oxygen Demand (BOD) were preserved by adding five ml of washed chloroform (chloroform and distilled water were taken in a separating funnel, shaken well, and the water layer was discarded) per litre of the sample.

Setting up the experiment

The soil samples were collected from different blocks of ADAC & RI, Trichy and were dried, processed, sieved filled in the pipes. For columnar study, PVC pipes of length 50 cm and diameter 7 cm were used. One end of the pipe was covered with a wire mesh and then through the other end first it was filled by gravel, then the soil was filled for a height of 30 cm and the amendments were added (5 cm) and the pipe was fitted to a wall. Then the other end of the pipe was fitted with a funnel to facilitate the collection of leachate. Then beakers were kept below the funnel for collecting the leachate. The raw distillery spent wash was not applied in dilution because dilution may reduce its acidity effect in reclaiming sodic soil.The leachates were collected at weekly intervals and their physico-chemical properties were analyzed.

Physico-chemical analysis of soil and spent wash

The physico-chemical properties of spent wash sample and soil sample were analysed on the basis of standard methods given by APHA, 1992. The change in physico-chemical properties of the soil samples were observed and analysed for 4 weeks in one week interval. Exchangeable cations (K, Mg, Ca) were extracted with 1 M NH_4OAc (pH 7.0) and analyzed by atomic absorption spectrophotometer. The biological oxygen demand (BOD) of sewage water was estimated using Winkler method [5] and chemical oxygen demand (COD) by using reflux method [6]. Total dissolved and suspended solids (mg/L) were measured as per the method given by APHA [15]. Exchangeable sodium percentage (%) is calculated using the formula:

Exchangeable Sodium Percentage = Exchangeable {(Na)/(Ca + Mg + K + Na)} x 100

RESULTS AND DISCUSSION

Physico-chemical analysis of the experimental soil

Chemical characteristics of experimental soils before the addition DRSW such as pH (1:2 sample:water suspension), electrical conductivity (EC), the amount of organic carbon, available nitrogen (N), available phosphorous (P), available potassium (K), exchangeable calcium (Ca), exchangeable magnesium (Mg) and exchangeable sodium content (Na) were analyzed and tabulated (Table 1). The exchangeable sodium percentage of the experimental soil was found to be 21.12 % which is high enough to be classified under sodic soil as 15% ESP is the threshold limit (Richards, 1954). The high pH of the soil (8.7) and high EC (0.45 dSm^{-1}) add to the justification of sodicity property of the experimental soil.

Physico-chemical analysis of the distillery spent wash sample:

Physico-chemical composition of the distillery raw spent wash (DRSW) sample such as pH(1:2 sample:water suspension), electrical conductivity (EC), total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD), biological oxygen demand (BOD) and organic carbon content were analyzed and tabulated (Table 2). Amount of total nitrogen, total phosphorus, total potassium, total calcium, total magnesium and total sodium contents are also presented (Table-2). The physico-chemical characteristics of the DRSW are given in Table 2. The DRSW is dark brown in colour with an unpleasant odour like that of caramelised sugar. The dark colour may be attributed to the presence of the reaction products of sugar amine condensation known as melanoidin [3]. Odourous compounds from distillery waste water mainly consist of volatile fatty acids such as butyric and valeric acids that have a high odour index. Distillery has distinct organic compositions. Various anaerobic bacteria ferment these compounds and generate products such as volatile fatty acids for example glycerol is fermented into butyric acid by clostridium butyricum [7]. Thiyagarajan [8] had reported the presence of skatole, indole and other sulphur compounds that are not completely decomposed by yeast or methane bacteria. This may be the primary cause of the unpleasant odour of the DRSW sample. The pH of the DRSW was found to be acidic (4.1), which may form the basic theory in using DRSW for reclamation of sodic soils. Among the total nutrients analysed, total potassium (12,378 mg L^{-1}) was present in larger amount than total calcium (4050 mg L^{-1}), total nitrogen (2800 mg L^{-1}), total magnesium (1800 mg L^{-1}) and total sodium (570 mg L^{-1}). The high EC of DRSW sample (27.2 dSm^{-1}) is mainly due to the high potassium salt content in the effluent [9].

Effect of distillery raw spent wash on soil pH

It was found that the pH of the spent wash was acidic in nature i.e. 4.1, which can be helpful in reducing the high pH of sodic soil i.e 8.7 denoting the dominance of sodium among the cations and carbonates/bicarbonates from anions [4]. After the treatment of raw distillery spent wash on the experimental soil, the pH starts decreasing at the first week itself i.e 8.2 from the initial value of 8.7. In the following weeks, it was also observed that, the pH kept on decreasing till 7.20 in fourth weeks (Table 3). It may be explained by the fact that the strongly acidic nature of the spent wash may have solubilised free lime in soil releasing Ca ions. These Ca ions replace exchangeable Na ions which in turn form soluble sodium salts. In addition to this, other cations and anions particularly Ca, Mg, K chlorides and sulphates present in raw spent wash might also have contributed for reducing the pH. This may also be attributed to the removal of carbonates and bicarbonates of sodium to a greater extent after reclamation. Similar reduction in pH was reported by Harron and Bose, [10].

Effect of distillery raw spent wash on soil EC

Electrical conductivity of the soil extract indicates concentration of soluble salts in the soil solution. From the experiment, it was found even though there was a buildup of EC during the first week but due to subsequent leaching process there was reduction in EC in later weeks (Table 3). Increased EC values were due to the soluble salts added to the soil through raw spent wash (EC 27.2 dSm^{-1}). However, EC values recorded in the soils were high enough to make the soil saline i.e. the EC values were less than the safer limit of 2 dSm^{-1} [3]. This might be due to leaching of salts through drainage. Results obtained are in accordance with the findings of Baskar *et al.,* [3].. This might be due to the presence of high concentration of soluble salts present in raw spent wash that were added to the soils at different levels.

Effect of Spent wash and different organic amendments on soil organic carbon

Distillery spent wash contain heavy load of organic matter as it is of plant origin. Perusals of the data revealed that there was a marginal increase in organic carbon content of soil at the end of the fourth week compared to the first week i.e from the initial value of 0.53 % to 2.84 %. (Table 3). The increase in organic carbon content of the soil might be due to the decomposition and humification of organic matter supplied through RSW. This is in line with the findings of Kayalvizhi *et al,* [12]. The results also support the findings of Devarajan et al., [13] who opined that the significant increase in the organic carbon content of the soil with distillery effluent irrigation would be attributed to the high load of organic carbon in the effluent. The spent wash with high BOD (12800 mg L^{-1}) and organic carbon (2.4%) content enriched the soil with organic matter which in turn increased the soil organic carbon. This is in accordance with Racault, [11] who reported that the distillery effluent was concentrated with soluble forms of organic matter.

Effect of distillery spent wash on soil exchangeable nutrients

Persual of the data revealed that there was a marginal increase in exchangeable calcium content of soil at the end of the fourth week (16.9 $cmol(p^+)kg^{-1}$) as compared to the first week (16.5 $cmol(p^+)kg^{-1}$). Similarly, in case of exchangeable magnesium, there was an increase from first week (3.50 $cmol(p^+)kg^{-1}$) to fourth week (3.90 $cmol(p^+)kg^{-1}$) as shown in Table 3. This might be attributed to leaching of Ca+Mg salts from the soil due to drainage. Increase in exchangeable Ca+Mg content after application of raw spent wash was attributed to greater replacement of exchangeable Na by the Ca+Mg ions released from the native soil $CaCO_3$ because of solubilization due to acidic nature of raw spent wash. Reduced exchangeable Ca+Mg in subsequent periods might be due to leaching effect brought about by application of good quality of water and the results obtained with regard to Ca+Mg concentration closely resemble the observations made by Chidankumar and Chandraju, [14]. There was a gradual decrease in exchangeable potassium and exchangeable sodium content of the soil as depicted in Table 3. This change was also reflected in decreasing values of EC that has been reported likewise by Sharma *et al.,* [9]. The gradual reduction of ESP at subsequent stages was due to slow replacement of highly bound exchangeable sodium on exchangeable site at lower levels of ESP. The marked decrease in ESP was noticed in sodic soil because of the presence of $CaCO_3$ that gets solubilized due to acidic nature of raw spent wash releasing free Ca ions which replace the sodium from the exchangeable sites. Similar findings were obtained when Saliha, 2003 use raw spent wash to reclaim sodic soils.

Table 1: Table showing the physico-chemical properties of the experimental soil before the application of RDSW

Sl.No.	Parameters	Unit	Values
1	pH	-	8.7
2	EC	(dSm^{-1})	0.45
3	Nitrogen	(kg ha^{-1})	207
4	Phosphorus	(kg ha^{-1})	17.12

5	Potassium	(kg ha^{-1})	315
6	Organic carbon	(%)	0.53
7	Exchangeable Ca^{+}	[c mol(p+)kg^{-1}]	16.1
8	Exchangeable Mg^{+}	[c mol(p+)kg^{-1}]	3.50
9	Exchangeable Na^{+}	[c mol(p+)kg^{-1}]	3.20
10	Exchangeable K^{+}	[c mol(p+)kg^{-1}]	0.48
11	ESP (Exchangeable Sodium Percentage)	%	21.12

Table 2: Table depicting the characteristics of the raw distillery spent wash

SI. No	Parameter	Values
1	Colour	Dark Brown
2	Odour	Unpleasant burnt sugar
3	pH	4.1
4	EC(dS/m)	27.2
5	BOD (5 days at 20^{0} C) (mg/L)	60,100
6	COD (5 days at 20^{0} C) (mg/L)	1,20,300
7	Total solids (mg/L)	96,450
8	Total dissolved solids (mg/L)	80,990
9	Total suspended Solids (mg/L)	42,765
10	Organic carbon (%)	6.4
11	Nitrogen (mg/L)	2800
12	Phosphorus (mg/L)	1200
13	Potassium (mg/L)	12,378
14	Calcium (mg/L)	4,050
15	Magnesium (mg/L)	1800
16	Sodium (mg/L)	570

Table 3: Table depicting change in physico-chemical properties of the sodic soil sample, reflecting the potential of RDSW as an efficient amendment for sodic soils (values of 5 replications)

Parameters	I week	II week	III week	IV week	Mean
Soil pH	8.2±0.04	8.00±0.01	7.46±0.04	7.20±0.02	**7.7**
Soil EC(dS/m)	0.55±0.12	0.54±0.8	0.49±0.4	0.46±0.3	**0.51**
Soil organic carbon (%)	2.77±0.04	2.79±0.09	2.82±0.03	2.84±0.04	**2.81**
Exchangeable calcium [c mol(p+)kg^{-1}]	16.5±0.18	17.1±0.08	16.8±0.9	16.9±0.10	**16.8**
Exchangeable sodium [c mol(p+)kg^{-1}]	3.12±0.23	3.10±0.17	2.97±0.07	2.82±0.14	**3.00**
Exchangeable potassium [c mol(p+)kg^{-1}]	0.56±0.06	0.48±0.1	0.45±0.10	0.40±0.06	**0.47**
Exchangeable magnesium [c mol(p+)kg^{-1}]	3.50±0.02	4.47±0.07	4.45±0.1	3.90±0.12	**4.08**
ESP (%)	18.5±0.1	15.4±0.6	11.6±0.1	9.3±0.8	**13.7**
Each value represents mean ± standard deviation. Each mean is the average of five replicates.					

CONCLUSION

Reduction in soil pH from 8.24 to 7.20, soil EC (dSm^{-1}) from 0.55 to 0.46, Exchangeable sodium (c mol (p^{+}) kg^{-1}) from 3.12 to 2.82 and ESP (%) from 18.5 to 9.3 in four weeks of treatment showed that continuous application of distillery spent wash may further reduce these values which are important in determining the efficiency of an amendment in reclaiming sodic soils. If the distillery spent wash finds its access to open drains, it may pose serious threats to water as well as soil quality. Therefore, as it is a good source of nutrients and organic matter, it can be used as a potential amendment in reclaiming sodic soils. The reuse of the distillery effluents in agriculture calls the attention of many workers associated with various waste clean-up programmes and may form one of the basic strategies of many missions. Further research on the application of distillery spent wash in agriculture would help the farmers to cut down costs of fertilizers and facilitate reduction of pollutant load in aquatic system. Farm trials in several locations as well as effect of different dilutions of distillery spent may be studied.

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CITATION OF THIS ARTICLE

A K Naorem, S K Udayana, N A K Singh and C. Selvaraj .Efficacy of Distillery Spent Wash as an Economical Soil Amendment for Sodic Soils.Bull. Env. Pharmacol. Life Sci., Vol 6[3] February 2017: 23-27