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Effect of Distillery Raw Spentwash on Soil Microbial Properties and Yield of Paddy in a Sodic *Vertisol*

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A B S T R A C T

To evaluate the effect of distillery RSW on soil microbial properties and yield of paddy in a sodic Vertisol a field study was conducted at Agricultural Research Station, Gangavathi, Koppal, Karnataka. The treatment consists of five graded levels of RSW, *viz*., 1.0, 1.5, 2.0, 2.5 and 3.0 lakh L ha^{-1} (T_1 to T_5), gypsum @ 50 and 100 per cent of gypsum requirement (GR) (T_6 and T_7) and control (T_8). The RDF applied to these treatments was common. The surface soil samples collected at harvest of the crop were examined for changes in physico-chemical properties, bacteria, fungi, actinomycetes, soil microbial biomass carbon, dehydrogease, urease and phosphatase activities. The soil pH, Ex-Na and ESP decreased with the levels of RSW application and decrement was linear with the proportion of RSW application. Apart from decreasing soil ESP it also enhanced the soil microbial activity. In general, the bacteria, fungi, actinomycetes, urease and phosphatase increased with increase in RSW application only up to 2.5 lakh L ha^{-1}. However, soil salinity build up was observed with the increased levels of RSW application. Paddy grain yield was significantly higher in T_4 and T_3 compared to other treatments, while significantly higher straw yield was recorded in T_5 compared to other treatments except T_4.

Introduction

In India, salt affected soils are broadly classified into two groups: sodic (alkali) and saline soils. As per the recent reconciled estimate (CSSRI, Karnal, NRSA, NBSS&LUP, 2006) nearly 6.73 M ha area is found to be salt affected (sodic soils: 3.77 M ha and saline soils: 2.96 M ha). In Karnataka state, nearly 4.14 L ha of land is being affected by salinity problem (Gupta *et al.*, 1995). It is reported that sodic soils known to occupy an area of about more than 15000 ha in the districts of Koppal, Bellary and Raichur of Northern Karnataka and over 28000 ha in Karnataka. In arid and semi-arid areas, where good-quality water for irrigated agriculture is scarce, inadequate management of soil and water resources can lead to soil sodification (Assouline *et al.,* 2015). Soil sodicity is characterized by a relatively high concentration of sodium in the exchange complex or in the soil water, causing adverse effects on the physical, chemical and biological properties of the soil. Among the soil microbial properties, the soil urease activity, acid and alkaline phosphatase activity in soils were reported to decrease with the increase in soil pH and ESP (Viraj Beri and Brar, 1978; Batra, 2010). Similarly, the soil microbial biomass, dehydrogenase activity and soil microbial biomass carbon observed to decrease due to a specific ion deficiencies and toxicities at high soil pH and ESP (Batra and Manna, 1997; Batra, 1998).

Distillery spentwash, a byproduct of alcohol industry is gaining its importance in the reclamation of non-saline sodic soils as it is highly acidic (pH=3.9-4.3) and contains fairly good amount of soluble organic matter, Ca (2050-7000 ppm), Mg and other essential plant nutrients. In India there are 400 distillery units with an average production of 3.80×10^9 L of alcohol generating 4.56×10^{10} L of spentwash (Verma chhaya and Rajesh Kumar, 2014). Karnataka has 25 working distilleries with an installed capacity of 250 M L with the annual production of 125 M L of alcohol generating 1500 M L of spentwash. The number of sugarcane crushing industries in Karnataka is also increasing. Alcohol industry continue to face the challenges of disposal of huge quantity of effluent without causing air, water and soil pollution due to its high organic load (high COD and BOD) which otherwise can be made use for the reclamation of non-saline sodic soil. Thus, application of distillery raw spentwash (RSW) to a sodic soil as an organic amendment and a source of plant nutrients is a promising alternative method for its safe disposal.

A significant research in the last 3-4 decades was carried out mainly on the use of raw spentwash (RSW) or pre-treated spentwash (PTSW) at proper dilutions as a source of nutrient in enhancing production of crops like wheat, maize, sugarcane, cow pea, red gram and black gram etc. (Chidankumar and Chandraju, 2008; Rath *et al.,* 2011). But, research on using RSW as an organic reclamative agent for sodic soil appears to be meager. Further, the research results from elsewhere reflect variation in the levels of dose of RSW applied depending on the soil and crop to be grown. The application rate varies as low as 1.5 lakh L ha^{-1} (sandy clay loam) to as high as 5.0 lakh L ha^{-1} (sandy loam). Information is lacking on using RSW as an organic amendment for sodic soils of the districts in Karnataka where heavy textured (clay/clay loam) soils are prominent. In a laboratory incubation study conducted by Saliha *et al.*, (2005) revealed that application of RSW at 55 ml kg^{-1} soil recorded significantly higher bacterial, fungal and actinomycetes colonies, urease and phophatase activity compared to control and other RSW treatments (110 and 225 ml kg^{-1} of soil). Further, increased concentration of spentwash in soil decreased the microbial population and enzyme activity. However, dehydrogenase activity (DHA) increased significantly with increased levels of RSW application. The indiscriminate use of RSW might adversely affect the soil microbial properties by increase in soil salinity. Therefore, the present study was aimed to examine the "Effect of distillery raw spentwash on soil microbial properties and yield of paddy in a sodic *Vertisol*".

Materials and Methods

A field experiment was conducted at the Agriculture Research Station (ARS), Gangavathi during *Kharif* 2014. The research site falls under the Northern Dry Zone of Karnataka state (semi-arid eco-subregion) lying between 15°35'07" N latitude and 76°15'47" E longitude at an altitude of 419 m above mean sea level with an average annual rainfall of around 542 mm. During the year 2014-2015 the rainfall received was about 29 per cent higher (763 mm) than the average rainfall of the station. Normally dry weather prevails over entire summer months with hottest period observed during April-May.

The mean maximum and minimum air temperature was ranged from 28.26 ^{o}C to 38.18 ^{o}C and 16.70 ^{o}C to 23.91 ^{o}C, respectively. The surface soil (0-15 cm) pH, ECe, bulk density, cation exchange capacity (CEC), Ex-Na and ESP before the start of the experimentation was 8.82, 1.32 dS m^{-1}, 1.35 Mg m^{-3}, 36.2 cmol (p^{+}) kg^{-1}, 7.1 cmol (p^{+}) kg^{-1} and 21.3%, respectively. The organic carbon content was medium (5.6 g kg^{-1}), soil microbial biomass carbon was 105.6 µg g^{-1} of soil, DHA was 1.15 µg TPF g^{-1} soil $24hr^{-1}$, urease and alkaline phosphatase activities were 6.34 µg NH_4-N g^{-1} soil hr^{-1} and 60.83 µg p-nitrophenol g^{-1} soil hr^{-1}, respectively. The soil microbial biomass like bacteria, fungi and actinomycetus populations were 10.59 CFU × 10^{-6} g^{-1} soil, 11.2 CFU × 10^{-4} g^{-1} soil and 19.08 CFU × 10^{-3} g^{-1} soil, respectively. The field experiment was laid out in a randomised complete block design with eight treatments consisting of five graded levels of RSW, *viz.*, 1.0, 1.5, 2.0, 2.5 and 3.0 lakh L ha^{-1} (T_1 to T_5), two levels of gypsum requirement (Gypsum @ 50 & 100% GR: T_6 & T_7) and control (T_8). All these treatments received RDF in common. During *Kharif* 2014, two months prior to transplanting of paddy, as one time application the required quantities of RSW and GR were applied manually to the plots (5m × 4m) as per treatments. The RSW was procured from "M/s. Vijayanagar Sugars Pvt. Ltd.", Mundaragi, Gadag, Karnataka. The properties of which were analyzed and presented in Table 1. Transplanted paddy (var. BPT 5204) was grown as a test crop to study the effect of RSW on grain yield.

The surface soils (0-15 cm) collected after the harvest of the paddy were analyzed for physico-chemical properties, microbial properties and enzyme activities to know the effect of levels of RSW application. The pH and EC of the soil was estimated in 1:2.5 soil: water suspension. The EC (1:2.5) values were multiplied by a common derived factor of 2.66 for soils at ARS, Gangavathi to convert them to ECe (dS m^{-1}); saturation paste extract values. The ESP was determined by using a formula ESP = $\frac{\text{Ex-Na}}{\text{CEC}} \times 100$ and expressed in per cent. The organic carbon content of the soil was determined by Walkley and Black method (Jackson, 1973).

The microbial population in moist surface soil was determined by serial dilution and plating technique as outlined by Waksman and Fred (1922). The soil microbial biomass carbon (SMBC) of the moist surface soil was determined by chloroform fumigation extraction method as outlined by Vance *et al.*, (1987). Dehydrogenase activity (DHA) in these soils was assayed by the method of Casida *et al.*, (1964) using 2,3,5-triphenyltetrazolium chloride (TTC) as the electron acceptor and expressing the results in µg TPF g^{-1} soil $24hr^{-1}$. The activity of urease was determined by NH_4-N distillation method as outlined by Bremner and Keeney (1966) and expressed in µg NH_4-N g^{-1} soil hr^{-1} and the phosphatase activity was determined by p-nitrophenyl phosphate method given by Tabatabi and Bremner (1969) and expressed in µg p-nitrophenol g^{-1} soil hr^{-1}.

Analysis of variance (ANOVA) was carried out using the randomised complete block design. Duncan's multiple range test (DMRT) at 5% level of probability was used to test the differences between means of individual treatments (Gomez and Gomez, 1984).

Results and Discussion

Chemical properties

Soil pH and electrical conductivity (ECe)

At crop harvest, the surface soil (0-15 cm) pH decreased significantly with increase in the levels of RSW and it varied from 7.68 (T_5) to 8.72 (T_8), respectively (Table 2). Among the treatments, T_5 (RSW @ 3.0 lakh L ha^{-1}) recorded significantly lower soil pH than other treatments but at par with T_4 (RSW @ 2.5 lakh L ha^{-1}) (7.82). Similarly, the soils amended with gypsum also decreased from 8.72 to 8.44 with increase in dose of gypsum application with T_7 (Gypsum @ 100% GR). The treatment T_2 (RSW @ 1.5 lakh L ha^{-1}) had similar effect as that of T_7. Decreased soil pH may be attributed to the replacement of Na^+ on the exchange complex by Ca^{2+} ions released into the soil and the acidic nature of RSW (pH 3.7). In addition, release of organic acids during the decomposition of organic matter (added through RSW) might have also solubilised the native lime and released free Ca^{2+} ions into the soil apart from high Ca content of RSW. In addition, increase in neutral soluble salts content of soils through application of RSW (EC 36.1 dS m^{-1}) also might have helped to decrease soil pH in RSW treated plots.

Unlike soil pH, the ECe increased significantly with increased levels RSW (Table 2). The soils treated with RSW recorded significantly higher ECe compared to control and gypsum treated plots. Among the treatments, significantly higher soil ECe (6.08 dS m^{-1}) was recorded under T_5 (RSW @ 3.0 lakh L ha^{-1}) compared to rest of the treatments which may be attributed to the contribution of salts from RSW which has high salt load in it (36.1 dS m^{-1}) (Table 2). Similar results were reported by Mahendra (2007), Bhagya Lakshmi (2009) and Hati *et al.,* (2007). The extent of buildup of soluble salt concentration above the critical limit (4 dS m^{-1} above which soils are classified as saline) particularly at higher rate of RSW application (3.0 lakh L ha^{-1}) is a cause of concern for increasing the rate of RSW application in such soils.

Soil exchangeable sodium (Ex-Na) and exchangeable sodium percentage (ESP)

In general, the soil Ex-Na and ESP decreased with the increased levels of RSW and the decrease was linear with the levels of RSW application. The decrease of Ex-Na and ESP at surface soil was significantly lower at the highest levels of RSW (T_5) application compared to T_1, T_2, T_6, T_7 and T_8 (Table 2). The per cent decrease in ESP over its initial levels was 75.2 (Table 2) in soils receiving RSW @ 3.0 lakh L ha^{-1}. Similarly, the application of gypsum @ 100% GR (T_7) has decreased the soil ESP from 21.58 to 16.38. However, the application of RSW @ 1.5 lakh L ha^{-1} had the same effect of gypsum @ 100% GR on soil ESP and apart from enriching the soil with organic matter and available macro and micronutrients. The decrease in Ex-Na and hence ESP might be due to replacement of Ex-Na on the clay colloid from Ca and leaching of Na^+ as soluble Na_2SO_4 as explained above. The results are in conformity with the findings of Bhagya Lakshmi (2009) who reported that the Ex-Na and ESP were decreased at harvest with higher levels of RSW application (7.5 lakh L ha^{-1}) from 10.44 to 5.91 cmol (p^+) kg^{-1} and ESP from 37.2 to 22.3 respectively. Similarly, in a pot culture experiment with sunflower as a test crop Mahendra (2007) also noticed that application of RSW at 4.5 lakh L ha^{-1} reduced ESP from 19.41 to 10.47.

Soil Microbial properties

Soil organic carbon (SOC), soil microbial biomass carbon and DHA

In general, the soil organic carbon increased significantly with increased levels of RSW application (Table 2). The SOC increased significantly from its initial 5.6 to 12.0 g kg^{-1} where higher rate of RSW application was applied (RSW @ 3.0 lakh L ha^{-1}) compared to rest of the treatments except T_4 (11.2) and T_3 (10.7 g kg^{-1}). Whereas, the increase of SOC was also noticed in soils treated with the gypsum but it was marginal as compared to RSW treated soils. The addition of organic carbon (4.01%) through RSW and associated better crop growth with increase in root biomass could probable be the reason for increase in soil organic carbon content particularly in RSW treated soils (Hati *et al.*, 2007). The results are also in line with the findings of Bhagyalakshmi, 2009 and Biswas *et al.*, 2009.

Table.1 Physico-chemical properties, chemical composition and biological properties of the distillery raw spentwash

Parameter	Spentwash	Parameter	Spentwash
pH	3.7	Total S (mg L^{-1})	2250
EC (dS m^{-1})	31.6	Bicarbonates (mg L^{-1})	13256
OC (%)	4.01	Zn (mg L^{-1})	7
COD (mg L^{-1})	96500	Fe (mg L^{-1})	85
BOD (mg L^{-1})	38500	Mn (mg L^{-1})	13.6
Total N (mg L^{-1})	5850	Cu (mg L^{-1})	5.8
Total P (mg L^{-1})	210	Cl (mg L^{-1})	9285
Total K (mg L^{-1})	14700	**Biological properties**	
Total Ca (mg L^{-1})	6377	Bacteria (CFU)	20×10^6 ml^{-1}
Total Mg (mg L^{-1})	3600	Fungi (CFU)	7×10^4 ml^{-1}
Total Na (mg L^{-1})	385	Actinomycetus (CFU)	3×10^2 ml^{-1}

Table.2 Effect of distillery raw spentwash on physico-chemical properties of the soil at harvest of the crop in a sodic Vertisol

Treatment	pH	ECe (dS m^{-1})	Ex-Na (cmol (p^+) kg^{-1})	ESP	OC (g kg^{-1})
T_1	8.34^{cd}	3.08^{d}	6.16^{bc}	17.02^{bc}	8.16^{bc}
T_2	8.27^{c}	3.27^{d}	5.51^{b}	15.28^{b}	9.07^{b}
T_3	7.96^{b}	4.51^{c}	4.69^{a}	12.96^{a}	10.70^{a}
T_4	7.82^{ab}	5.43^{b}	4.46^{a}	12.32^{a}	11.19^{a}
T_5	7.68^{a}	6.08^{a}	4.40^{a}	12.15^{a}	12.01^{a}
T_6	8.51^{d}	1.75^{ef}	6.75^{c}	18.65^{c}	6.65^{d}
T_7	8.44^{cd}	2.08^{e}	5.93^{bc}	16.38^{b}	6.86^{cd}
T_8	8.72^{e}	1.46^{f}	7.81^{d}	21.58^{d}	6.45^{d}

Table.3 Effect of distillery raw spentwash on soil microbial population at harvest of the crop in a sodic Vertisol

Treatment	Bacteria (CFU × 10^7 g^{-1} soil)	Fungi (CFU × 10^4 g^{-1} soil)	Actinomycetes CFU × 10^5 g^{-1} soil)
T_1	4.19^{cd}	13.6^{cd}	16.3^{cd}
T_2	4.86^{c}	15.3^{c}	19.1^{c}
T_3	6.16^{b}	17.8^{b}	23.8^{b}
T_4	7.75^{a}	22.3^{a}	31.2^{a}
T_5	7.11^{a}	20.6^{a}	28.4^{a}
T_6	3.07^{ef}	10.5^{ef}	12.5^{ef}
T_7	$3.40d^{e}$	11.8^{de}	14.9^{de}
T_8	2.33^{f}	9.2^{e}	11.3^{f}

Table.4 Effect of distillery raw spentwash on soil enzyme activities at harvest of the crop in a sodic Vertisol

Treatment	SMBC (µg g^{-1} soil)	DHA (µg TPF g^{-1} soil $24hr^{-1}$)	Phosphatase (µg PNP g^{-1} soil hr^{-1})	Urease (µg NH_4-N g^{-1} soil hr^{-1})
T_1	209.9^{d}	3.25^{c}	229.5^{d}	23.42^{c}
T_2	256.2^{c}	4.76^{b}	312.3^{c}	26.46^{c}
T_3	268.7^{bc}	5.05^{ab}	382.2^{b}	31.33^{b}
T_4	288.7^{ab}	5.70^{ab}	475.9^{a}	38.83^{a}
T_5	301.9^{a}	5.89^{a}	437.4^{a}	36.13^{a}
T_6	159.7^{e}	2.18^{d}	148.9^{e}	15.12^{d}
T_7	165.1^{e}	2.67^{cd}	170.7^{e}	18.34^{d}
T_8	148.0^{e}	1.87^{d}	124.3^{e}	9.28^{e}

Table.5 Effect of distillery raw spentwash on yield of paddy in a sodic Vertisol

Treatments	Plant height (cm)	Tiller $hill^{-1}$	Productive tillers $hill^{-1}$	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 (RSW @ 1.0 lakh L ha^{-1})	86.6^{bc}	17.5^{c}	14.4^{bc}	4198^{cd}	5284^{d}
T_2 (RSW @ 1.5 lakh L ha^{-1})	88.4^{b}	18.6^{bc}	16.4^{ab}	4388^{c}	5593^{cd}
T_3 (RSW @ 2.0 lakh L ha^{-1})	98.6^{a}	21.1^{ab}	18.9^{a}	4913^{ab}	6129^{bc}
T_4 (RSW @ 2.5 lakh L ha^{-1})	99.7^{a}	21.4^{ab}	19.0^{a}	5006^{a}	6462^{ab}
T_5 (RSW @ 3.0 lakh L ha^{-1})	100.5^{a}	22.6^{a}	18.0^{a}	4544^{bc}	6706^{a}
T_6 (Gypsum @ 50% GR)	79.2^{bc}	12.4^{de}	11.3^{de}	3622^{e}	4131^{ef}
T_7 (Gypsum @ 100% GR)	81.6^{bc}	14.1^{d}	13.0^{cd}	3909^{de}	4526^{e}
T_8 (Control)	76.8^{c}	10.6^{e}	9.6^{e}	3481^{e}	3841^{f}

The SMBC increased with graded levels of RSW application. The SMBC increased from 105.6 to 301.9 µg g^{-1} dry soil where the highest level of RSW was applied (Table 4). Among the treatments, T_5 (RSW @ 3.0 lakh L ha^{-1}**)** recorded significantly higher SMBC (301.9 µg g^{-1} dry soil) compared to rest of the treatments except T_4. The distillery RSW contains considerable amount of easily degradable organic matter which would stimulate soil microbial biomass, microbial activity and consequently the SMBC. The results are in agreement with the findings of Hati *et al.*, (2007) who reported increase in SMBC from 130.5 (control) to 359.6 mg kg^{-1} (179%) with the application of RSW at 7.5 lakh L ha^{-1}. Similar to SMBC, the DHA increased with increased levels of RSW application (Table 4) with T_5 recording significantly higher DHA (5.89 µg g^{-1} dry soil $24hr^{-1}$) compared to T_1, T_2, T_3, T_6, T_7 and T_8 but at par with the T_4 (RSW @ 2.5 lakh L ha^{-1}).

Soil microbial biomass and enzyme activity

The soil microbial population is concurrent with pH, EC, ESP and fertility of the soil. In accordance with the decrease in soil pH, ESP and increase in organic carbon content, the microbial population *viz*., bacteria, fungi and actinomycetes at rhizosphere soil (0-15 cm) increased significantly with increased levels RSW up to 2.5 lakh L ha^{-1} but decreased slightly at 3.0 lakh L ha^{-1} (Table 3). However, higher salt build up in soil (ECe 6.08 dS m^{-1}) at higher level of RSW (3.0 lakh L ha^{-1}) might have caused reduction in microbial population. In an incubation study, Saliha *et al.*, (2005) reported that the microbial population in sodic soil was higher under lower levels of RSW application (55 ml kg^{-1} soil) as compared higher levels of RSW (225 ml kg^{-1} soil). The bacteria, fungi and actinomycetes population ranged from 2.33 to 7.75 CFU × 10^7 g^{-1} soil, 9.2 to 22.3 CFU × 10^4 g^{-1} soil and 11.3 to 31.2 CFU × 10^5 g^{-1} soil, respectively. The lower and higher bacteria, fungi and actinomycetes populations were recorded in T_8 (Control+ RDF) and T_4 (RSW @ 2.5 lakh L ha^{-1}) respectively. As indicated by Baskar *et al.*, (2013), high organic carbon content and nutrients of distillery RSW (Table 1) would serve as ready energy source for the growth, enzyme processes and multiplication of microbes.

The urease and alkaline phosphatase activity was significantly higher (38.83 µg NH_4-N g^{-1} soil hr^{-1} & 475.9 µg PNP g^{-1} soil hr^{-1}) in soils receiving RSW at 2.5 lakh L ha^{-1} compared to other treatments except T_5 (RSW @ 3.0 lakh L ha^{-1}) where a marginal decrease was observed (Table 4). As discussed above, 2-3 folds increase in enzyme activity in RSW treated soils might be attributed to decrease in soil pH, increase in organic matter and microbial population. Similar to microbial biomass, decrease in these activities at higher levels (RSW @ 3.0 lakh L ha^{-1}) might be due to "Salting out" effect of Cl^- which might have modified the ionic confirmation of active centre of enzymes and subsequent specific ion toxicities caused by nutritional imbalance for the adequate synthesis of enzymes (Saliha *et al.*, 2005). Saliha *et al.*, (2005) also reported an increase in phosphatase (392%) and urease (140%) activity from 26 (control) to 128.1 g kg^{-1} hr^{-1} and 1.9 and 28.6 g kg^{-1} hr^{-1} respectively with the application of RSW at 55 ml kg^{-1} soil followed by RSW at 110 ml kg^{-1} soil at 60 days after incubation. Similar effect of RSW application on phosphatase and urease activity was also reported by Murugaragavan (2002).

Paddy yield

The plant height, number of tillers and productive tillers per hill, grain and straw yield increased significantly with increased levels of RSW application and the increase may be attributed to improvement in soil physico-chemical properties along with enhanced fertility status of the soil which in turn might have promoted better root development, nutrient content and its uptake by the crops and higher biomass production (Table 5). Among the treatments, T_5 recorded significantly higher plant height, number of tillers per hill and straw yield compared T_1, T_2, T_6, T_7 and T_8 but at par with T_4 and T_3. However, the number of productive tillers per hill and grain yield were significantly higher in T_4 (RSW @ 2.5 lakh L ha^{-1}) compared to T_1, T_2, T_5, T_6, T_7 and T_8 but at par with T_3.

The results are in agreement with the findings of Saliha (2003) who reported that the application of RSW at the rate of 125 m^3 ha^{-1} recorded significantly higher rice grain yield than at 250 and 500 m^3 ha^{-1}. Similar effect of RSW application on yield was also reported by Hati *et al.,* (2007) and Biswas *et al.*, (2009) for soybean and wheat; Balasubramanian *et al.,* (2007) for rice crop, respectively.

It is evident from the above study that the application of RSW at about 2.0 lakh L ha^{-1} appears to be ideal for increasing soil microbial population and enzyme activities of a sodic *Vertisol*. The buildup of soil salinity and thus increased ionic concentrations and toxicity of specific ions at higher rates of RSW application might have adversely affected the growth of soil microbial biomass and consequently reduced enzyme activity. The positive effects of one time application of RSW @ 2.0 lakh L ha^{-1} on soil physico-chemical and biological properties reflected in improved plant growth and yield of paddy.

References

Assouline, S., Russo. D. and Silber, A., 2015, Balancing water scarcity and quality for sustainable irrigated agriculture: Balancing water scarcity and quality for irrigation. *Water Resour. Res.*, 51: 3419-3436.

Balasubramanian, V., Paneerselvan, P., Manickam, T. S. and Jayakumar, R., 2007, Evaluation of cropping systems in partially reclaimed sodic soils of North western zone of Karnataka. In *National conference on ecofriendly utilization of recyclable organic resources from sugar and distillery industries for sustainable agriculture*, Tamilnadu Agricultural University, Trichy, March 6-7.

Baskar, M., Saravanan, A., Chitra, L., Dhevagi, P., Lenin Raj, D., Pandiyarajan, P. and Ambast. S. K., 2013, Bulletin on "*Ecofriendly utilization of distillery waste water in agriculture*", AICRP on Management of salt affected soils and use of saline water in Agriculture, Karnal, Haryana. pp 1-50.

Batra, L. and Manna, M. C., 1997, Dehydrogenase activity and microbial biomass carbon in salt affected soils of semiarid and arid regions. *Arid Soil Res. Rehabil*., 11 (3): 295-303.

Batra, L., 1998, Effect of different cropping sequences on dehydrogenase activity of three sodic soils*. J. Indian Soc. Soil Sci*., 46 (3): 370-375.

Batra, L., 2010, Phosphatase and urease enzymes in saline and sodic soils and their correlation with some soil chemical properties. *J. Soil. Salinity & Water Qual*., 2 (2): 69-74.

Bhagya Lakshmi, T., 2009, Utilization of distillery spent wash for reclamation of sodic soil and ferti-irrigation studies in rice. *Ph. D. (Agri.) Thesis*, Univ. Agric. Sci., Bengalore, Karnataka (India).

Biswas, A. K., Mohanty, M., Hati, K. M. and Misra, A. K., 2009, Distillery effluent effect on soil organic carbon and aggregate stability of a Vertisol in India. *Soil Tillage Res*., 104: 241-246.

Bremner, J. M. and Keeney, D. R., 1966, Determination and isotope analysis of different forms of nitrogen in soils. Exchangeable ammonium nitrate and nitrite by extraction-distillation methods. *Soil. Sci. Soc. Amer. Proc*., 30: 577-582.

Casida Jr, L. E., Klevin, D. A., and Santoro, T., 1965, Soil Dehydrogenase activity. *Soil Sci*., 93: 371-376.

Chidankumar, C. S. and Chandraju, S., 2008, Impact of irrigation of distillery pentwash on the nutrients of pulses in untreated and treated soil. *Sugar Tech*., 10 (4): 314-318.

Gomez, K. A. and Gomez, A. A., 1984. Statistical Procedure for Agricultural Research, 2nd ed. John Wiley and Sons, Singapore.

Gupta, I. C., Sharma, D. P. and Gupta, S. K., 1995, Alkali Wastelands Environment and Reclamation, *Scientific Publishers*, *Jodhpur*, India.

Hati, K. M., Biswas, A. K., Bandyopadhyay, K. K. and Misra, A. K., 2007, Soil properties and crop yields on a vertisol in India with application of distillery effluent. *Soil Tillage Res*., 92: 60-68.

Jackson, M. L., 1973, Soil chemical analysis. *Prentice Hall of India. Pvt. Ltd*., New Delhi.

Mahendra, A. C., 2007, Studies on reclamation of sodic soils through distillery spentwash. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Murugaragavan, R., 2002, Distillery spentwash on crop production in dryland soils. *M. Sc. (Agri.) Thesis*, Tamil Nadu Agric. Univ., Coimbatore, Tamil Nadu (India).

Rath, P., Pradhan, G. and Misra, M. K., 2011, Effect of distillery spent wash (DSW) and fertilizer on growth and chlorophyll content of sugarcane (*Saccharum officinarum* L.) Plant. *Recent Res. Sci. Techno.*, 3 (4): 169-176.

Saliha, B. B., 2003, Ecofriendly utilization of distillery spentwash for improving agricultural productivity in dry land and high pH soils of Theni district. *Ph.D. (Agri.) Thesis*, Tamil Nadu Agric. Univ., AC & RI, Madurai, Tamil Nadu (India).

Saliha, S. B., Krishnakumar, S., Saravanan, A. and Natarajan, S. K., 2005, Microbial and enzyme dynamics in distillery spentwash treated soil. *Res. J. Agric. Biol. Sci.*, 1: 166–169.

Tabatabai, M. A. and Bremner, J. M., 1969, Use of p-nitrophenyl phosphate for the assay of soil phosphatase activity. *Soil Biol. Biochem*., 1:301-307.

Vance, E. D., Brookes, P. C. and Jenkinson, D. S., 1987, An extraction method for measuring soil microbial biomass C. *Soil Biol. Biochem*., 19: 703-707.

Verma chhaya and Rajesh Kumar, 2014, Utilization of distillery waste water in fertigation: A beneficail use. *Int. J. Res. Chem. Environ*., 4 (4): 1-9.

Viraj Beri and Brar, S. S., 1978, Urease activity in subtropical, Alkaline soils of India. *Soil Sci*., 126 (6): 330-335.

Waksman, S. A. and Fred, E. B., 1922, A tentative outline of the plate method for determining the number of microorganisms in soil. *Soil Sci.*, 14: 27-28.

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