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INFLUENCE OF LONG-TERM SPENTWASH APPLICATION ON PHYSICO-CHEMICAL PROPERTIES OF VERTISOLS OF NORTHERN TRANSITION ZONE OF KARNATAKA

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Abstract: A field experiment was conducted in the long-term trial on distillery spentwash application established since 2003 at the Main Agricultural Research Station, UAS, Dharwad. The study was carried out during kharif 2012. The experiment consisted of seven treatments and 3 replications. Long-term application of spentwash to supply 1½ recommended nitrogen reduced the soil bulk density and increased the porosity. Water stable aggregates and maximum water holding capacity of the soil was improved with higher dose and long-term usage of spentwash. Soil organic carbon and inorganic carbon contents increased significantly with long-term application of spentwash. Soil reaction remained neutral and electrical conductivity was not adversely affected by the long-term application of spentwash.

Key words: Spentwash, Maize, Soil physical properties, Soil chemical properties

INTRODUCTION

Molasses based industries all over the world generate large amount of effluent termed as spentwash, which is unwanted residual liquid waste generated during alcohol production. Total waste water produced per litre of alcohol production is around 8- 12 litres (Anon, 2012). In India, there are around 400 distilleries with a production capacity of about 3800 million litres of alcohol generating 40 billion litres of waste water annually. It has high BOD and COD and contains high organic compounds like phenols, lignin, oil and grease which deteriote the surrounding ecosystem quality. As the effluent is mainly a plant extract, rich in organic matter and plant nutrients like potassium, nitrogen, sulphur and calcium, there is a scope for using it advantageously as a source for ferti-irrigation to agricultural crops without any adverse effect on soil fertility and productivity. Raw spentwash has a low pH of 3-5.4, high EC of 5-23.7 dS m^{-1}, high BOD of 32,800- 43,200 mg L^{-1}, high COD of 76,000- 1,08,000 mg L^{-1} and 7- 9 per cent TDS. In order to suppress the impact of BOD, COD and salinity, biomethanation process is recommended where in the raw spentwash is subjected to anaerobic decomposition process yielding methane, a fuel and thereby the BOD level is brought down. Both raw and biomethanated spentwash has 0.1–0.15 per cent N, 0.8-1.2 per cent K_2O and appreciable quantities of Ca, Mg, S and micronutrients. On an average 1 m^3 of spentwash supplies 1.0 kg N, 0.2 kg P_2O_5 and 10 kg K_2O (Anon, 2006). However, this treated spentwash could not be directly applied to the growing crops because of higher BOD and COD than the permissible limits. So, it should be applied well before the planting of crop or diluted with normal water and then applied to the growing crops or as one time controlled land application applied before one month of the planting. Present study was conducted to assess long-term effect of spentwash on soil physical and chemical properties.

MATERIALS AND METHODS

The experiment was being conducted in the Main Agricultural Research Station, Dharwad under Vertisols since 2003 with fixed treatments. The present study was conducted during kharif (2012) with maize as the test crop. The soil of the experimental site is Typic Chromustert. The experiment was laid out in a randomized complete block design with three replications and seven treatments. The properties of spentwash used in the experiment is given Table 1. The details of the treatments were; T1- 1 N through spentwash (60,000 litre ha^{-1}+ balanced P through SSP); T2 – 1 ½ N through spentwash (90,000 litre ha^{-1} + balanced P through SSP); T3– 1 N through recommended dose of fertilizer (150:75:37.5 kg NP_2K_2O ha^{-1}); T4– 1½ N through recommended dose of fertilizer (225:75:37.5 kg NP_2K_2O ha^{-1}); T5 – ½ N through fertilizer + ½ N through spentwash; T6 – ½ N through spentwash + ½ N through fertilizer and T7 – Farmers' practice (2 bags DAP + 1 bag urea= 41:46:0 NP_2K_2O kg ha^{-1}). Required quantity of spentwash was calculated as per the nitrogen levels in the treatments. Sixty per cent of the spentwash was applied uniformly 15 days before sowing the crop and 40 per cent was applied at tasseling stage. Phosphorus was applied in the form of SSP in treatments with spentwash and DAP in fertilizer treatments. In treatments without spentwash, nitrogen was applied in the form of urea and DAP and potassium through Muriate of potash. Soil samples were collected from individual plots before sowing the crop and after harvest. Collected soil samples were analysed for physical properties like bulk density, porosity, maximum water holding capacity and aggregate stability, chemical properties like pH (1:2.5 soil water ratio), EC, soil organic and inorganic carbon and exchangeable cations. All the chemical analysis was carried out by adopting standard analytical procedures.

Table 1. Characteristics of distillery spentwash used for experimentation

Parameter	Value
Colour	Dark brown
Odour	Bad
pH	7.47
Electrical conductivity (dS m^{-1})	16-18
Biological oxygen demand (mg l^{-1})	5,500
Chemical oxygen demand (mg l^{-1})	15,750
Total solids (mg l^{-1})	20,120
Total dissolved solids (mg l^{-1})	15,350
Suspended solids (mg l^{-1})	4,770
Chlorides (mg l^{-1})	5,570
Sodium (mg l^{-1})	220
Potassium (mg l^{-1})	6,750
Calcium (mg l^{-1})	750
Magnesium (mg l^{-1})	1,250
Total Nitrogen (mg l^{-1})	2,600
Total phosphates (mg l^{-1})	152
Zinc (mg l^{-1})	17.23
Iron (mg l^{-1})	54.34
Manganese (mg l^{-1})	9.88

RESULTS AND DISCUSSION

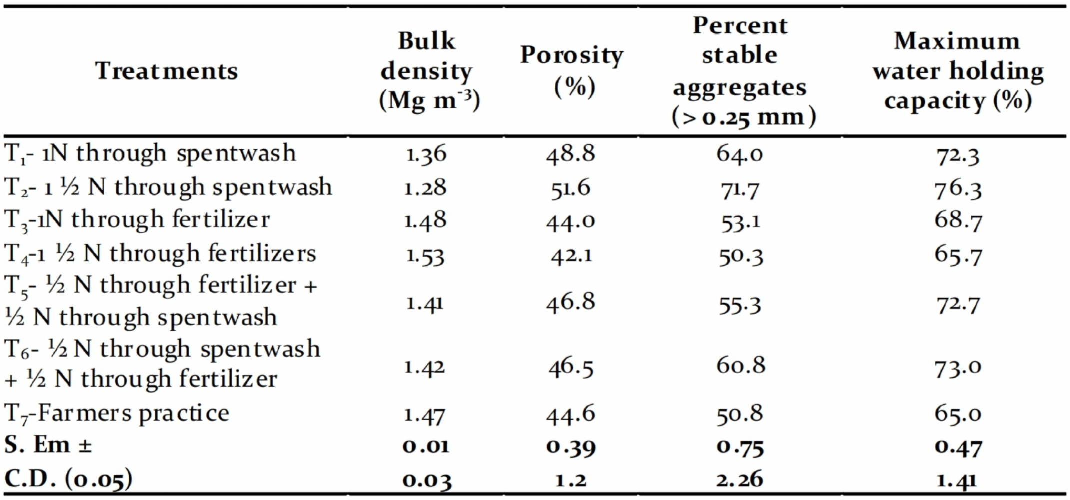
Soil physical properties

Increasing dose of long-term spentwash application significantly reduced bulk density of the surface soil (Table 2). Minimum value of 1.28 Mg m^{-3} was recorded in the treatment that was applied with 1½ N through spentwash. Bulk density was the maximum in the treatment that received 1½ N through fertilizers (1.53 Mg m^{3}) which remained on par with the treatment that received 1 N through fertilizer and farmers' practice. Application of spentwash to serve 1.5 times recommended nitrogen was high enough to bring significant reduction in the bulk density compared to equivalent dose of fertilizer. Reduction in bulk density was due to addition of high organic matter through spentwash. Such reduction in bulk density due to spentwash addition was also reported by Kumar and Chopra (2011) where minimum bulk density was obtained in 100 per cent spentwash irrigated treatment compared to control. Subash Chandra Bose *et al.,* (2002) reported that application of graded doses of distillery effluent progressively reduced bulk density and increased water holding capacity of the sandy soil.

The highest porosity of 51.6 per cent was recorded in the treatment that received 1½ N through spentwash followed by the one with 1 N through spentwash (48.8 per cent). Per cent porosity was lesser in the treatments with fertilizer application at the rate of 1 N or 1½ N. Per cent water stable aggregates (> 0.25 mm) had been significantly improved by the long-term spentwash fertigation. The data indicated that the treatment that received 1½ N through spentwash recorded the highest per cent water stable aggregates (71.7 %) and was significantly higher than all the other treatments. The lowest per cent stable aggregates (50.8 %) was noticed in farmers' practice. This was on par for the treatments with 1 N and 1½ N through fertilizers.

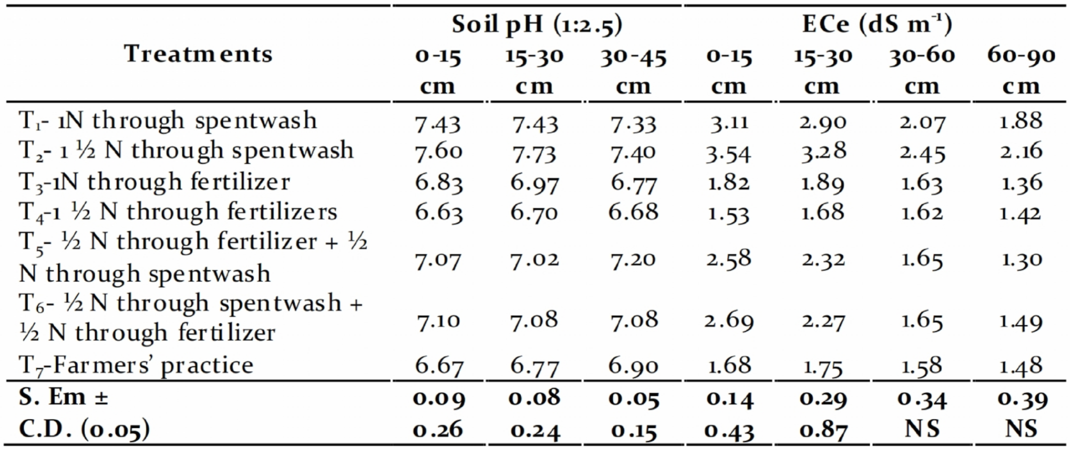
Long-term application of spentwash had significant influence on maximum water holding capacity of the soil. Maximum water

Table 2. Effect of long-term spentwash application on soil physical properties after harvest



Treatments	Bulk density (Mg m^{-3})	Porosity (%)	Percent stable aggregates (> 0.25 mm)	Maximum water holding capacity (%)
T_1- 1N through spentwash	1.36	48.8	64.0	72.3
T_2- 1 ½ N through spentwash	1.28	51.6	71.7	76.3
T_3-1N through fertilizer	1.48	44.0	53.1	68.7
T_4-1 ½ N through fertilizers	1.53	42.1	50.3	65.7
T_5- ½ N through fertilizer + ½ N through spentwash	1.41	46.8	55.3	72.7
T_6- ½ N through spentwash + ½ N through fertilizer	1.42	46.5	60.8	73.0
T_7-Farmers practice	1.47	44.6	50.8	65.0
S. Em ±	**0.01**	**0.39**	**0.75**	**0.47**
C.D. (0.05)	**0.03**	**1.2**	**2.26**	**1.41**

Table 3. Effect of long-term spentwash application on soil pH and electrical conductivity after harvest



Treatments	Soil pH (1:2.5)			ECe (dS m^{-1})			
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-60 cm	60-90 cm
T_1- 1N through spentwash	7.43	7.43	7.33	3.11	2.90	2.07	1.88
T_2- 1 ½ N through spentwash	7.60	7.73	7.40	3.54	3.28	2.45	2.16
T_3-1N through fertilizer	6.83	6.97	6.77	1.82	1.89	1.63	1.36
T_4-1 ½ N through fertilizers	6.63	6.70	6.68	1.53	1.68	1.62	1.42
T_5- ½ N through fertilizer + ½ N through spentwash	7.07	7.02	7.20	2.58	2.32	1.65	1.30
T_6- ½ N through spentwash + ½ N through fertilizer	7.10	7.08	7.08	2.69	2.27	1.65	1.49
T_7-Farmers' practice	6.67	6.77	6.90	1.68	1.75	1.58	1.48
S. Em ±	**0.09**	**0.08**	**0.05**	**0.14**	**0.29**	**0.34**	**0.39**
C.D. (0.05)	**0.26**	**0.24**	**0.15**	**0.43**	**0.87**	**NS**	**NS**

holding capacity was higher in treatments where there was spentwash application, either alone or in combination with fertilizers. It ranged from 65 to 76.3 per cent. The treatment with 1½ N through spentwash had recorded the highest maximum water holding capacity. The lowest maximum water holding capacity (65.0 per cent) was recorded in the treatment with farmers' practice which was on par with treatment where 1½ N was supplied through fertilizers. Increased aggregate stability might be due to the salts present in the spentwash and also the fresh application of effluent might had stimulated the microbial activity and secretion of microbial polysaccharides, which helped in stabilisation of soil aggregates. Higher concentration of Ca in soil solution and exchangeable sites under spentwash applied plots might have improved aggregation and its strength. Increase in per cent porosity in spentwash treated plots was ascribed to higher organic matter content and changing distribution of pore sizes of the soil. An increase in maximum water holding capacity was due to increased number of small pores caused by better and fine grade aggregation. Water holding capacity was related to the number and size distribution of soil pores and consequently increased with soil organic matter level. This was in agreement with the findings of Kumar and Chopra (2011). Hati *et al.* (2007) reported that the mean weight diameter, saturated hydraulic conductivity, water retention capacity and available water content were significantly higher, while bulk density and penetration resistance of the surface soil were significantly lower in all distillery effluent treated plots. The porosity was 1.15 times higher in treatment with 1.5 N through spentwash compared to farmers' practice. Higher easily decomposable organic matter content and enhanced microbial activities in spentwash applied treatments had improved all the physical properties of soil.

Soil chemical Properties

Data on soil pH (Table 3) implies that the soil reaction was in neutral range in spentwash fertigated plots. Soil pH at 0-15, 15-30 and 30-45 cm depth was significantly influenced by the fertilizer and spentwash application. The highest pH (7.73) was observed in the treatment with 1½ N through spentwash in 15-30 cm depth soil. Treatments with combination of spentwash and chemical fertilizers remained on par with each other. The pH was slightly lower in treatments with fertilizer compared to spentwash application. This was due to continuous application of biomethanated spentwash which was neutral to basic in reaction. Such an increase in soil pH due long-term spentwash application was reported by Pradeep (2007) and Subash Chandra Bose *et al.* (2002). Goudar (2006) also reported that the pH of the soils were neutral to alkaline in reaction in pedons irrigated with spentwash for more than 20 years.

The ECe data after the harvest of the crop (Table 3) indicated that there was no development of salinity in the soil. However, the electrical conductivity was measured to be the highest (3.54 dS m^{-1}) in the treatment that received higher dose of spentwash (1½ N through spentwash). There was no accumulation of salts in the deeper layers since the electrical conductivity decreased with depth in all treatments and soil salinity did not differ among treatments at 30-60 and 60-90 cm depth. The lowest soil salinity in the surface layer was observed in farmers' practice, 1 N and 1½ N application through fertilizer. Slight Increase in ECe with spentwash application, particularly at higher concentration is a cause of concern for its application in the long run. In the long run indiscriminate application might create problem of soil salinity. Increase in ECe was due the higher EC of the spenwash (16-18 dSm^{-1}), which indicated the high salt load of the spentwash. This result was in agreement with Bhukya (2006). Further, Kumar and Chopra (2011), Hati *et al.* (2007) and Subash Chandra Bose *et al.* (2002) reported that increase in the rate of application of effluent significantly increased the EC of the soil.

The soil organic carbon content (Table 4) showed significant differences among the treatments after harvest of the crop. The highest organic carbon content (9.70 g kg^{-1}) was recorded in the treatment that was supplied with 1½ N through spentwash. Combined application of spentwash and chemical fertilizers also resulted in increase of organic carbon compared to farmers' practice. The lowest organic carbon content (5.97 g/kg) was recorded in farmers' practice. Addition of organic matter through spentwash and better crop growth with concomitant increase in the root biomass could be the probable reasons for the increase in the organic carbon content in the soil with higher quantity of spentwash application. Similar result was reported by Kumar and Chopra (2011), Bhukya (2006) and Pradeep (2007).

Long-term spentwash fertigation influenced the soil inorganic carbon only in the surface layer (Table 4). The highest inorganic carbon (29.75 g kg^{-1}) was recorded in the treatment that was supplied with 1½ N through spentwash. There was no significant change in inorganic carbon in the lower layers. Spentwash application either at 1N or 1½ N doses remained on par with each other with respect to soil inorganic carbon. Organic carbon and potassium present in the spentwash improved the CO_2 evolution by enhancing the microbial activity. The CO_2 might have solubilized the carbonates in soil and thus increased the inorganic carbon. The study was supported by findings of Suresh Chandra *et al.* (2002) and Thippeswamy and Manjunath (2011).

Critical examination of the data (Table 5) revealed that there was an increase in exchangeable sodium with increase in depth in all the treatments. The exchangeable Na ranged from 1.01 to 1.28 cmol (p^+) kg^{-1} in the 0-15 cm soil. It was the highest (1.54 cmol (p^+) kg^{-1}) in the treatment that received 1½ N through spentwash at 30-45 cm depth. The exchangeable

Table 4. Effect of long-term spentwash application on soil organic and inorganic carbon after harvest

Treatments	Soil organic carbon ($g\ kg^{-1}$)			Soil inorganic carbon ($g\ kg^{-1}$)		
	0-15	15-30	30-45 cm	0-15	15-30	30-45
	cm					
T_1- 1N through spentwash	8.17	6.93	5.73	29.65	29.33	29.30
T_2- 1 ½ N through spentwash	9.70	7.40	6.87	29.75	29.79	29.45
T_3-1N through fertilizer	6.43	5.80	5.20	29.53	29.30	29.38
T_4-1 ½ N through fertilizers	6.10	5.70	5.10	29.28	29.65	29.80
T_5- ½ N through fertilizer + ½ N through spentwash	8.03	6.13	6.23	29.65	29.55	29.40
T_6- ½ N through spentwash + ½ N through fertilizer	8.37	6.63	6.53	29.42	29.67	29.89
T_7-Farmers practice	5.97	5.07	5.40	29.25	29.84	29.50
S. Em ±	**0.26**	**0.13**	**0.23**	**0.09**	**0.12**	**0.23**
C.D. (0.05)	**0.79**	**0.38**	**0.69**	**0.27**	**NS**	**NS**

Table 5. Effect of long-term spentwash fertigation on exchangeable cations after harvest

Treatments	Ca^{++}+ Mg^{++} (cmol (p^+) kg^{-1})			Na^+ (cmol (p^+)kg^{-1})			K^+ (cmol (p^+)kg^{-1})		
	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
	cm								
T_1- 1N through spentwash	74.0	73.7	74.4	1.25	1.36	1.48	2.17	2.05	1.70
T_2- 1 ½ N through spentwash	76.5	77.0	75.6	1.28	1.38	1.54	2.51	2.26	1.99
T_3-1N through fertilizer	70.0	70.0	69.4	1.12	1.29	1.37	0.98	0.90	0.96
T_4-1 ½ N through fertilizers	71.7	70.8	70.8	1.10	1.25	1.34	0.91	0.93	0.91
T_5- ½ N through fertilizer + ½ N through spentwash	72.7	70.2	72.7	1.22	1.30	1.42	1.61	1.51	1.48
T_6- ½ N through spentwash + ½ N through fertilizer	72.7	70.6	71.9	1.20	1.33	1.44	1.71	1.57	1.52
T_7-Farmers practice	69.0	71.9	66.7	1.01	1.16	1.26	0.96	0.96	0.93
S. Em ±	**0.93**	**2.07**	**1.20**	**0.04**	**0.04**	**0.02**	**0.03**	**0.03**	**0.03**
C.D. (0.05)	**2.71**	**NS**	**3.63**	**0.12**	**0.12**	**0.05**	**0.09**	**0.10**	**0.10**

sodium did not differ significantly in the treatments with combined application of spentwash and chemical fertilizers inspite of which one was applied first. The exchangeable potassium was higher in the treatments with spentwash application. The data showed that there was decrease in exchangeable potassium with increase in depth. The highest exchangeable potassium (2.51 cmol (p^+) kg^{-1}) in the surface layer was observed in the treatment with 1½ N through spentwash. This was followed by treatment applied with spentwash at 1 N. Data on the exchangeable cations (Table 5) showed that calcium and magnesium were the dominant ions on the exchangeable sites. Exchangeable calcium and magnesium in soil was significantly influenced by spentwash application in the surface layer. The treatment with 1½ N through spentwash recorded the highest exchangeable calcium and magnesium

(76.5 cmol (p+) kg-1). The results obtained were in agreement with observations made by Goudar (2006).

CONCLUSIONS

Long-term application of spentwash influenced the soil physico-chemical properties. Soil reaction and EC were not adversely affected by the long-term application of spentwash. Application of spentwash and chemical fertilizers in combination was found to be superior than application of chemical fertilizer alone. Thus, application of distillery spentwash to agricultural field as a liquid fertilizer is a viable option for the safe disposal of this industrial waste with concomitant enhancement in yield and improvement in soil properties.

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