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Nutrient status of Soil as influenced by application of distillery spentwash R O Reject

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Abstract
Distillery spentwash R O reject is the waste water obtained during production of ethanol. Preliminary analysis of this spentwash revealed that it contains large amounts of plant nutrients. So, to check the effect of this spentwash application to soil on nutrient status and fertility an experiment was conducted. The experiment consisted of seven treatments laid out in Randomized Complete Block Design with three replications. The results indicated that the application of distillery spentwash R O reject to soil increased nutrient status of soil compared to initial status. Among the treatments, treatment receiving 150% N through distillery spentwash R O reject significantly increased the nitrogen (283.7 kg ha^{-1}), phosphorus (24.1 kg ha^{-1}), potassium (1213.5 kg ha^{-1}), secondary and micronutrients in soil compared to all other treatments. Significantly lower content of nitrogen, phosphorus, potassium (193.6, 10.6 and 588.5 kg ha^{-1}, respectively) and other nutrient elements were recorded in treatment RDF only.

Keywords: Distillery; Micronutrients; Nitrogen; Nutrient status; R O reject

Introduction
Rapid rate of industrialization has accelerated soil and water pollution around the industrial units due to unscientific methods of discharge of waste materials on land or into water bodies. Distilleries are one of the most important agro based industries in India producing alcohol from molasses, which is a by-product of sugar factories. More than 90% of ethanol in India is mainly produced by fermentation of diluted molasses by employing different microbial strains. Spentwash is a dark brown coloured liquid with an unpleasant odour of burnt sugar. The dark brown colour of raw spentwash is due to the presence of melanoidin of cane molasses which is not decomposed effectively by yeast and methane bacteria in its activated sludge process.

Distillery spentwash (DSW) R O reject is the waste water which was obtained after the molasses subjected for reverse osmosis (RO) process which is a separation process that uses pressure to force a solution through a membrane that retains the solute on one side and allows the pure solvent to pass to the other side.

Due to its large volume as well as high BOD and COD makes it a serious concern for disposal of distillery effluent. The effluent doesn't contain any toxic metals as it is a waste from plant based sugar mills; rather it contains major and micro-nutrients which are helpful for sustaining the soil fertility and the yield of crops. Because of this it can be applied directly to the land as irrigation water as it helps in restoring and maintaining soil fertility, increasing soil micro flora, improving physical and chemical properties of the soil leading to better water retaining capacity of the soil.

It is said that the nutrient supplying capacity of soil is decreasing day by day due to intensive agriculture and non-addition of organic manures. Therefore, the application of nutrients needs to be increased to keep the soil fertile and to make agriculture sustainable, but the cost of inorganic fertilizer is increasing. On the other hand during recent years, sugar industries are producing large amount of waste products some of which are rich sources of macro, micro and secondary nutrients. In this background, to find out an alternate source of nutrients to crops, a field experiment on "Nutrient status of Soil as influenced by application of distillery spentwash R O reject" was conducted during *kharif* 2013-14 and the results are presented in this paper.

Material and methods
The experiment was conducted in the farmer's field near J. P. Distilleries Pvt. Ltd. Heggadathihalli village, Kunigal taluk, Tumkur district, situated in the southern dry zone (Zone-6) of Karnataka (India) during *kharif* 2013-14 and maize (*Zea mays* L.) was taken as test crop. The soil of the experimental site was sandy clay loam in texture belong to the order *Alfisol*. The initial soil properties of the experimental site are given in table 1.

Table 1: Initial soil characteristics of the experimental site.

Soil Properties	Values	Soil Properties	Values
pH	6.48	Sulphur (ppm)	19.10
EC (dsm^{-1})	0.14	Iron (ppm)	21.28
CEC [cmol (p^{+}) kg^{-1}]	8.9	Magnesium (me/100g)	2.4
Organic carbon (%)	0.55	Sulphur (ppm)	19.10
Av. Nitrogen (kg ha^{-1})	248.37	Iron (ppm)	21.28
Av. Phosphorus (kg ha^{-1})	22.69	Zinc (ppm)	0.38
Av. Potassium (kg ha^{-1})	652.51	Manganese (ppm)	23.20
Calcium (me/100g)	3.6	Copper (ppm)	0.60
Magnesium (me/100g)	2.4	Boron (ppm)	0.18

seven treatments laid out in Randomized Complete Block Design with three replications. Recommended dose of fertilizer: 100:50:25 kg N: P_2O_5: K_2O ha^{-1} was given. The spacing was maintained at 60 cm X 30 cm and NAH-1137 (HEMA) is a 120 days duration maize variety was used. The distillery spentwash R O reject was applied one month prior to sowing. The chemical composition of distillery spentwash R O reject is given in table 2. Soil sampling was done before application of distillery spentwash R O reject, one month after application of distillery spentwash R O reject (before sowing of the crop), at knee high stage of maize and after harvest of the crop and subjected for analysis with respect to different nutrients following the standard procedures.

The experiment consisted of 7 treatments *viz.*, T_1: RDF only; T_2: RDF + FYM; T_3: 50% N through DSW R.O. Reject + 50%N through fertilizer; T_4: 75% N through DSW R.O. Reject + 25%N through fertilizer; T_5: 100% N through DSW R.O. Reject; T_6: 125% N through DSW R.O. Reject; and T_7: 150% N through DSW R.O. Reject.

Table 2: Physico-chemical characteristics of distillery spentwash R. O. reject.

Parameters	Values	Parameters	Values
Colour	Dark brown	Calcium (mg L^{-1})	1932
pH	7.29	Magnesium (mg L^{-1})	1202.4
EC (dsm^{-1})	44	Sulphur (mg L^{-1})	430.01
Organic carbon (%)	0.9	Iron (mg L^{-1})	48.66
Total suspended solids (mg L^{-1})	37100	Zinc (mg L^{-1})	5.12
Total dissolved solids (mg L^{-1})	48000	Manganese (mg L^{-1})	6.98
BOD (mg L^{-1})	53560	Copper (mg L^{-1})	4.5
COD (mg L^{-1})	87280	Boron (mg L^{-1})	26.4
Nitrogen (%)	0.18	Chlorides (mg L^{-1})	7139.1
Phosphorus (mg L^{-1})	450.2	Bicarbonates (mg L^{-1})	86.7
Potassium (mg L^{-1})	11887		

Statistical analysis

The data collected were analyzed statistically following the procedure as described by Panse and Sukhatme (1967) [8]. The level of significance used in 'F' and 't' test was *P=0.05*. Critical differences were calculated using the 't' test wherever 'F' test was significant.

Results and discussion

Soil pH, electrical conductivity (EC) and organic carbon as influenced by application of distillery spentwash R O reject. The soil pH was found to be significantly increased with the application of distillery spentwash R O reject one month before sowing (Fig. 1). The highest pH value was observed in treatment receiving 150% N through DSW R.O. reject (T_7) (7.32) followed by 125% N through DSW R.O. reject (T_6) (7.10). The addition of basic cations like Ca from spentwash might have increased the pH of soil. Similar results were reported by Basker *et al*. (2001) [1] and Subash Chandra Bose *et al*. (2002) [13] who reported that application of graded dose of distillery effluent significantly increased the pH.

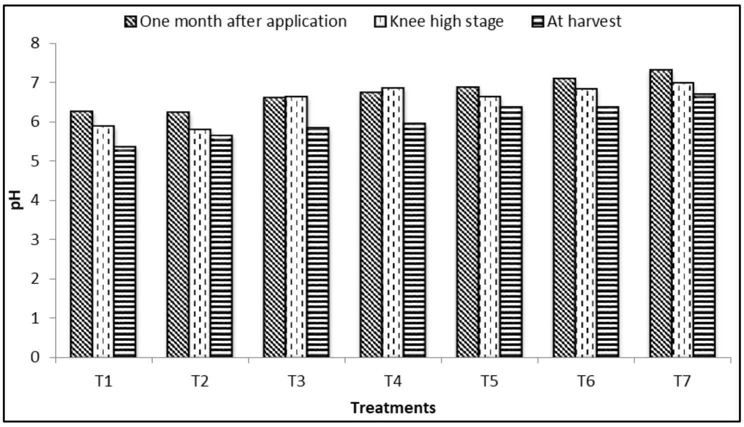

Fig 1: Effect of application of distillery spent wash R. O. reject on pH of soil.

The pH of soil samples progressively decreased at knee high stage and at harvest of maize (Fig. 1). The decrease in pH of soil samples might be due to uptake of alkaline earth materials like Ca by crop and might also be due to leaching of salts from the soil due to high rainfall. It was also possible that the organic matter present in the spentwash decomposes in soil and released organic acids which might have reduced the soil pH.

Significant increase in soil EC (Fig. 2) was noticed due to application of distillery spentwash R O reject at different quantities based on N levels at the time of sowing. The highest EC (0.98 dSm^{-1}) value was observed in treatment receiving 150% N through DSW R.O. reject (T_7) followed by 125% N through DSW R.O. reject (T_6) (0.95 dSm^{-1}). This increase was quite expected as the distillery spentwash R O reject had an EC of 44 dS m^{-1} due to heavy loads of salts. Increase in EC after distillery effluent application was also reported by Selvamurugan *et al.* (2013) [11] and Basker *et al*. (2001) [1]. Lowest EC was recorded in RDF only (T_1) (0.23 dSm^{-1}).

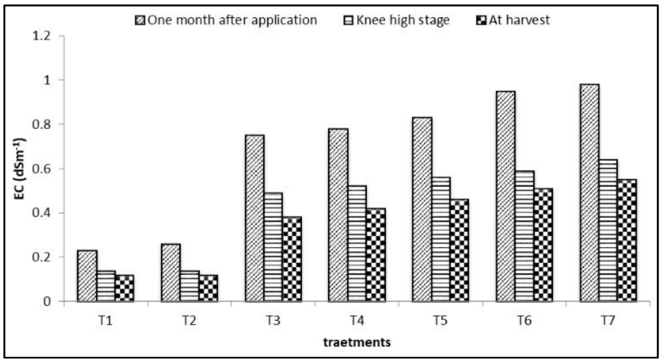

Fig 2: Effect of application of distillery spent wash R. O. reject on electrical conductivity (EC) of soil

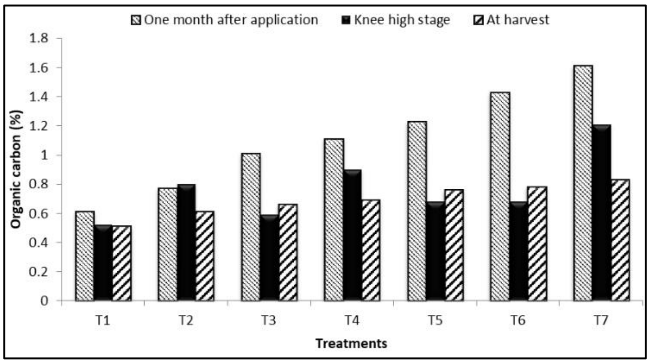

Fig 3: Effect of application of distillery spent wash R. O. reject on organic carbon content of soil

Similar to the soil pH, EC of the soil was also progressively decreased at knee high stage and at harvest of maize. This reduction in EC observed may be due to crop removal and / or due to the leaching of salts from surface to subsurface soil. Selvakumar (2006) [10] also noted an increase in soil EC within the safe limit of 1.0 dSm-1 due to the application of distillery spentwash, which is in accordance with the findings of the present study. However, long term experiments are to be conducted to draw any definite conclusions.

The organic carbon content of soil was significantly increased (Fig. 3) due to application of different quantities of distillery spentwash R O reject over control at the time of sowing. The spentwash with high BOD and organic carbon content enriches the soil with organic matter. The decomposition and humification of the organic matter in soil supplied through distillery effluent, in turn increased the soil organic carbon. Similar results were reported by Gopal *et al.* (2001) [2] and Selvakumar (2006) [10] which are in close agreement with the present findings.

During crop growth there was a decreasing trend in organic carbon content of soil (at knee high and harvest stages of maize). The organic carbon content was found to decrease irrespective of the levels of spentwash added, particularly towards the end of the harvest stage. It could be due to the decomposition of organic matter and carbon loss mainly as CO_2 from soil. Similar results were reported by Gopal *et al.* (2001) [10] and Jeyasubha *et al.* (2001) [3].

Available nitrogen, phosphorus and potassium as influenced by application of distillery spentwash R O reject

The changes in soil available nitrogen, phosphorus and potassium due to application of distillery spentwash R O reject one month after application are presented in Table 3. Significantly higher amount of available nitrogen, phosphorus and potassium were recorded in treatment receiving 150% N through distillery spentwash R.O. reject (T_7) (423.5, 44.9 and 1649.0 kg ha^{-1}, respectively) followed by treatment receiving 125% N through DSW R.O. reject (T_6) (391.1, 33.7 and 1478.3 kg ha^{-1}, respectively) and T_5 (100% N through DSW R.O. reject) (364.0, 31.7 and 1317.9 kg ha^{-1}, respectively). Lower values of available nitrogen, phosphorus and potassium content of soil were recorded in treatment T_1 (RDF only) **(**238.2, 22.6 and 653.2 kg ha^{-1}, respectively).

The higher rate of mineralization and release of N from soil and high nitrogen content of spentwash could have contributed for increase in the available N content of the soil. Math *et al.* (2011) [6] and Satisha (2000) [9] reported that spentwash application increased the soil available N content. Increasing dose of spentwash application increased the N availability in soil and this could be due to the higher N supply from the spentwash (1200 mg l^{-1}). A significant increase in available P in the soil due to the addition of P and HCO_3 through distillery spentwash and production of organic acids would have helped in the solubility of the native soil P. Similar results were reported by Murugaraghavan (2002) [7]. The decomposition processes of easily degradable organics might have reduced the binding energy and P sorption capacity of the soil favouring higher P availability in the soil. Increase in soil K was due to application of spentwash which might be due to fact that K was one of the main components of spentwash supplied in large quantities. These results are in agreement with Shenbagavalli *et al*. (2011) [12] and Kalaiselvi and Mahimairaja (2010) [4].

At knee high stage of maize (Table 3), significantly higher amount of available nitrogen, phosphorus and potassium were recorded in treatment receiving 150% N through distillery spentwash R.O. reject (T_7) (342.9, 29.6 and 1378.1 kg ha^{-1}, respectively) followed by T_6 (125% N through DSW R.O. reject) (329.8, 26.9 and 1268.6 kg ha^{-1}, respectively) and T_5 (100% N through DSW R.O. reject) (287.3, 22.0 and 1210.7 kg ha^{-1}, respectively). The lowest available of nitrogen and potassium values were recorded in treatment T_1 (RDF only) (216.9, 17.2 and 600.2 kg ha^{-1}, respectively).

Table 3: Effect of application of distillery spent wash R. O. reject on available nitrogen, phosphorus and potassium content ((kg ha^{-1})) of soil.

Treatments	One month after application			Knee high stage			At harvest		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	238.2	27.6	653.2	216.9	17.2	600.2	193.6	10.6	588.5
T_2	249.2	26.8	671.2	242.2	21.9	643.6	211.3	17.9	638.1
T_3	296.0	39.8	986.2	233.9	23.4	858.1	187.9	10.9	741.6
T_4	328.4	26.8	1152.6	250.6	21.2	1007.9	179.6	19.1	893.1
T_5	364.0	31.7	1317.9	287.3	22.0	1210.7	207.1	12.9	1005.3
T_6	391.1	33.7	1478.3	329.8	26.9	1268.6	245.3	18.3	1150.7
T_7	423.5	44.9	1649.0	342.9	29.6	1378.1	283.7	24.1	1213.5
SEm±	4.95	2.89	2.67	9.58	2.27	58.62	11.58	2.35	26.54
CD at 5 %	15.27	8.89	8.24	29.52	6.99	180.64	35.67	7.23	81.79
CV (%)	2.62	16.34	0.41	6.10	16.96	10.20	9.30	25.01	5.17

Samples collected after the harvest of crop (Table 3) shown that significantly higher amount of available nitrogen and phosphorus were recorded in treatment receiving 150% N through distillery spentwash R.O. reject (T_7) (283.7 and 24.1 kg ha^{-1}, respectively) followed by T_6 (125% N through DSW R.O. reject) (245.3 and 18.3 kg ha^{-1}, respectively). Treatments T_2 (RDF + FYM) (211.3 and 17.9 kg ha^{-1}, respectively) and T_4 (75% N through DSW R.O. reject + 25%N through fertilizer) (179.6 and 19.1 kg ha^{-1}, respectively) were found to be on par with each other. The treatments T_3 (50% N through DSW R.O. reject + 50%N through fertilizer) (187.9 and 10.9 kg ha^{-1}, respectively) and T_5 (100% N through DSW R.O. reject) (207.1 and 12.9 kg ha^{-1}, respectively) were found to be on par with each other. Lowest available nitrogen and phosphorus content was recorded in T_1 (RDF only) (193.6 and 10.6 kg ha^{-1}, respectively) treatment. Significantly higher available potassium value was recorded in treatment T_7 (150% N through DSW R.O. reject) (1213.5 kg ha^{-1}) followed by T_6 (125% N through DSW R.O. reject) (1150.7 kg ha^{-1}).

A progressive decline in the available N content of soil was observed with the advancement of the crop growth which might be due to the continuous removal of nitrogen by crop, losses due to leaching, volatilization and fixation in the clay lattice. The decline in available phosphorus at knee high and harvest stages of maize could be due to crop uptake, physico-chemical immobilization of phosphorus (adsorption, precipitation etc.) into insoluble forms. The available K content of soil decreased as the growth of crop advances towards harvest and the decline could be attributed to the higher uptake of K by the crop.

Exchangeable calcium, magnesium and available sulphur as influenced by application of distillery spentwash R O reject

The changes in the exchangeable calcium, magnesium and available sulphur content of soil due to application of distillery spentwash R O reject one month after application are presented in Table 4. There was significant change in soil exchangeable calcium, magnesium and available sulphur content. The highest value of Ca, Mg and S was in treatment receiving 150% N through distillery spentwash R.O. reject (T_7) (4.70, 2.43 cmol (P^+) kg^{-1} and 34.64 ppm, respectively) followed by T_5 (100% N through DSW R.O. reject) (4.47, 2.03 cmol (P^+) kg^{-1} and 30.04 ppm, respectively). The treatments T_2 (RDF + FYM) (4.23, 2.23 cmol (P^+) kg^{-1} and 23.20 ppm, respectively) and T_3 (50% N through DSW R.O. reject + 50%N through fertilizer) (4.27, 2.10 cmol (P^+) kg^{-1} and 25.52 ppm, respectively) were found on par with each other. The lowest Ca, Mg and S content was recorded in T_1 (RDF only) (3.07, 1.53 cmol (P^+) kg^{-1} and 19.63 ppm, respectively).

Table 4: Effect of application of distillery spent wash R. O. reject on exchangeable calcium and magnesium ((Cmol P^+ kg^{-1})) and available sulphur ((ppm)) content of soil.

Treatments	One month after application			Knee high stage			At harvest		
	Ca	Mg	S	Ca	Mg	S	Ca	Mg	S
T_1	3.07	1.53	19.63	4.00	1.93	19.03	2.43	1.07	18.68
T_2	4.23	2.23	23.28	4.10	1.87	23.67	2.33	1.27	20.22
T_3	4.07	2.10	25.52	3.67	1.50	23.15	2.30	1.07	20.47
T_4	3.87	2.20	29.23	3.70	1.73	23.47	2.50	1.07	21.64
T_5	4.47	2.03	30.04	4.20	1.90	31.67	2.57	1.10	22.74
T_6	4.10	2.03	29.36	3.60	2.07	23.67	2.50	1.17	23.32
T_7	4.70	2.43	34.64	3.60	1.97	34.15	3.30	1.37	25.61
SEm±	0.24	0.11	1.89	0.42	0.29	1.94	0.23	0.09	1.26
CD at 5 %	0.74	0.34	5.81	NS	NS	5.99	NS	NS	3.88
CV (%)	10.17	9.06	11.93	18.83	26.96	13.17	15.83	14.79	10.01

The increase in Ca and Mg content could be due to higher Ca (1932 mg l^{-1}) and Mg (1202.4 mg l^{-1}) contents in spentwash as reported by Kayalvizhi *et al.* (2001) [5]. The increase in sulphur content of soil might be due to sulphur supplied to soil through distillery spentwash as it had good amount of sulphur (430.0 mg L^{-1}). Similar results were reported by Vinod Kumar and Chopra (2013) [14].

There was no significant variation in the exchangeable calcium and magnesium (at knee high stage) content of soil. However the available sulpur content (Table 4) of soil varied significantly and highest value was in treatment receiving 150% N through distillery spentwash R.O. reject (T_7) (34.2 ppm) followed by T_5 (100% N through DSW R.O. reject) (31.7 ppm). The treatments T_2 (RDF + FYM) (23.7 ppm) and T_6 (125% N through DSW R.O. reject) (23.7 ppm) were found on par with each other with respect to available sulphur.

At the harvest of the crop there was no significant difference in exchangeable calcium and magnesium contents of soil due to application of distillery spentwash R O reject (Table 4). Significantly higher amount of available sulphur was recorded in treatment T_7 (150% N through distillery spentwash R.O. reject) (25.6 ppm) followed by T_6 (125% N through DSW R.O. reject) (23.3 ppm). Treatments T_5 (100% N through DSW R.O. reject) (22.7 ppm) and T_4 (75% N through DSW R.O. reject + 25% N through fertilizer) (21.6 ppm) were found to be on par each other. The available sulphur content of soil was lowest in T_1 (RDF only) (18.7 ppm) treatment.

As the crop growth advances towards harvest, the exchangeable Ca and Mg contents of the soil decreased and the variation was non-significant among the treatments. The decrease in Ca, Mg and S contents of soil might be due to removal of these nutrient elements by the crop.

Micronutrients content of soil as influenced by application of distillery spentwash R O reject

The changes in DTPA-extractable micronutrients like Fe, Mn, Zn and Cu in soil due to application of distillery spentwash R O reject one month after application are presented in Table 5. There was no significant change in DTPA-extractable Fe, Mn, Zn and Cu content of soil due to application of distillery spentwash R O reject. However higher amount of Fe, Mn and Cu (24.05, 28.06 and 1.23 ppm, respectively) were found in treatment T_6 (125% N through DSW R.O. reject). The higher value for Zn was in T_7 (150% N through distillery spentwash R.O. reject) (0.80ppm). Irrespective of the treatments, the micronutrients contents were slightly higher in distillery spentwash R O reject applied plots. The slight increase in micronutrient contents of soil might be due to addition of micronutrients through distillery spentwash R O reject.

Table 5: Effect of application of distillery spent wash R. O. reject on micronutrient (ppm) status of soil.

Treatments	One month after application				Knee high stage				At harvest			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1	21.65	27.70	0.73	1.02	21.53	26.84	0.79	0.81	15.37	18.80	0.51	0.48
T_2	22.10	27.50	0.71	1.05	19.54	27.01	0.73	0.86	15.32	18.71	0.45	0.45
T_3	21.90	27.65	0.77	1.17	21.58	27.12	0.71	0.84	16.25	27.41	0.50	0.49
T_4	23.17	27.61	0.74	1.15	21.60	27.05	0.64	0.85	14.99	26.81	0.56	0.48
T_5	23.12	27.71	0.75	1.22	20.77	27.75	0.79	0.84	15.31	23.43	0.50	0.49
T_6	24.05	28.06	0.77	1.23	22.38	26.98	0.74	0.77	13.80	22.81	0.54	0.39
T_7	23.99	27.84	0.80	0.99	21.32	26.88	0.77	0.75	14.47	28.11	0.56	0.44
SEm±	0.58	0.24	0.05	0.06	1.49	0.32	0.03	0.052	1.34	2.62	0.03	0.03
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.41	1.47	10.75	9.29	12.17	2.01	11.13	11.09	15.43	19.15	9.39	9.86

Both at knee high stage and harvest of the crop there was no significant variation in DTPA-extractable Fe, Mn, Zn and Cu content of soil due to application of distillery spentwash R O reject (Table 5). There was a decrease in micronutrient contents of soil at knee high and harvest stages of maize compared to the contents before sowing. This decrease might be due to uptake of micronutriens by the crop. Gopal *et al.* (2001)[2] reported higher content of soil organic carbon, macro and micronutrients and soil microbial population due to application of distillery effluent.

Conclusion

The distillery spentwash R O reject is waste water discharged by distilleries can be utilized as a source of nutrients as it contains high amounts of essential nutrients. Application of distillery spentwash R.O. reject to soil resulted in increased organic carbon content and nutrient status of soil compared to initial values. The nutrient status of soil increased with increase in quantity of distillery spentwash R O reject. Nutrient status of soil decreased at the end of the crop season due to removal by crop as well as different losses. It is concluded that, application of distillery spentwash R O reject helps in adding organic matter and nutrients to soil thereby increasing nutrient status of soil as well as soil fertility which results in the increased soil productivity.

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