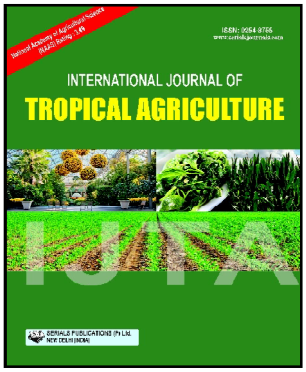

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Effect of Long-term Soil Application of Treated Distillery Spent Wash on Soil Health and Wheat Yield

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Abstract: Observations on chemical and microbial properties were recorded in a field experiment conducted in the long-term trial on the soil application of bio-methanted distillery spent wash monitored by Department of Environment Science since 2003 at the Main Agricultural Research Station, UAS, Dharwad. This study was conducted in a maize-wheat cropping system on vertisols. The soil was analysed for pH, Ece, organic and inorganic carbon along with exchangeable cations. Microbial activity in soil was determined by analysing dehydrogenase and phosphatase activity. Application of spent wash continuously, in the long run, brought major changes in the chemical properties of soil. Soil reaction (pH) was remained neutral whereas, slight Increase in EC with spent wash application, particularly at higher concentration is a cause of concern for its application in the long run. Organic and inorganic carbon was higher in the spent wash treatments. Similarly, exchangeable cations, water soluble cations and anions were found to have increased with long-term spent wash application indicating its possible adverse effects on soil health because of continuous use. The dehydrogenase and phosphatase activities in the spent wash irrigated plots were also higher than the fertiliser applied plots. This might be attributed to higher organic load present in the spent wash, which might have served as a source of energy for the growth and multiplication of micro-organisms and also for various enzyme activities in soil.

Keywords: Spent wash, soil health, exchangeable cations, soil organic and inorganic carbon.

INTRODUCTION

Spent wash (effluent) a byproduct of distilleries generated after fermentation and distillation of molasses for alcohol contains essential plant nutrients. Use of spent wash is forbidden in any facets of environment because of its low pH, higher conductivity along with very high chemical oxygen demand (COD) and biological oxygen demand

(BOD). Above all it has several organic compounds like phenols, lignin, oil and grease which deteriorate the surrounding ecosystem. Total waste water produced per litre of alcohol production is around 8-12 litres. In India, there are around 400 distilleries with a production capacity of about 3800 million liters of alcohol generating 40 billion liters of waste water annually. 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 ferti-irrigation source to agricultural crops. Pollution potential of the spent wash may be ameliorated by biomethanation process where in the raw spent wash is subjected to anaerobic decomposition process yielding methane, a fuel and thereby the BOD level is brought down. Biomethanated spent wash 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. However, this treated spent wash can be used for agriculture activities if BOD and COD levels will remain well within the permissible limits. So, the options left over is to mix well in agricultural fields as one time controlled land application applied before one month of the planting or diluted with normal water and then applied to the growing crops.

In certain areas, the scarcity of water has forced the farmers to use the treated spent wash, as a substitute for irrigation water over the years. Crops have shown good response to treated distillery effluent application (Jadhav & Savant, 1975; and Zalawadia & Raman, 1994). Dongale & Savant (1978) opined that spent wash was as good as murriate of potash as a source of potassium for sorghum. Kulkarni *et al.* (1987) classified spent wash as diluted liquid organic fertilizer with high potassium contents and its nitrogen was mostly in colloidal form behaving as a slow release fertilizer better than most inorganic nitrogen sources. Since the conventional methods of spent wash treatment are uneconomical and especially difficult in handling and transporting of large quantities, alternative methods like application to nearby agricultural lands is receiving increasing attention as source of plant nutrients and irrigation water. Keeping the above points in view, a long term experiment was conducted to know the utility of spent wash on wheat yield and its impact on soil health.

A long term field experiment on the utility of spent wash as source of plant nutrients was conducted from 2004 to 2013 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. The soil of the experimental field was Vertisol with clay texture, alkaline in reaction and had low electrical conductivity. The organic carbon content was 5.2 g/kg soil. The available nitrogen, phosphorus and potassium content of the initial soil was 221, 32.4 and 318.7 kg/ha, respectively. The secondary treated spent wash from SLN Distilleries, Garag of Dharwad district was used for the experiment. In the present study the effluent was applied based on the nitrogen requirement of the crop (recommended dose of fertilizers is 30:30:20 N, P_2O_5 & K_2O Kg/ha). Forty per cent of the recommended nitrogen was applied through spent wash 15 days before sowing and remaining 60 % after sowing in the splits of 20 % each in the next three irrigations *viz.,* at crown root initiation, late vegetation and flower initiation stage. Quantitatively, the supply phosphorus was lower, while, potassium was much higher than the recommended for the crop. The deficit in the P requirement was met by applying super phosphate fertilizer. Wheat crop was raised in Complete Randomized Block Design with the following treatments with three replications:

T_1 = RDN through spent wash

T_2 = 1 ½RDN through spent wash

T_3 = RDN through chemical fertilizer

T_4 = 1 ½ RDN through chemical fertilizer

T_5 = ½RDN through fertilizer (at sowing) + ½RDN through spent wash (top dressing)

T_6 = ½RDN through spent wash (at sowing) + ½RDN through fertilizer (top dressing)

T_7 = Farmers practice (30:30:20 N: P_2O_5: K_2O Kg ha^{-1} at the time of sowing)

At maturity, wheat was harvested to record grain and biomass yield. Soil samples collected after harvesting the crop were analyzed for pH, EC, organic carbon, available nitrogen and potassium contents by following the standard laboratory methods. Saturated hydraulic conductivity, bulk density and volumetric water content were also determined following the method prescribed by Black (1965). Microbial population of bacteria, fungi and actinomycetes was enumerated.

RESULTS AND DISCUSSION

Characteristics of spent wash: On an average it contained appreciable amounts of plant nutrients; especially it was high in potassium content (5940 mg/l.). Total N content was 0.09 % (Table 1). Spent wash is in dark brown colour with alkaline pH, high EC (18 dS/m). The BOD was around 5360 mg/l, while its COD was around 16000 mg/l. Doddamani *et al.*, (2003) also recorded similar nutrient content and nature of distillery effluent. In the present investigation, the BOD of the spent wash although higher (5360 mg/l), its application rate was on the basis of nutrient requirement followed by irrigation.

Effect on wheat yield: Performance of the crop under chemical fertilizer and spent wash management was evaluated in terms of grain yield. Continuous use of treated spent wash on the fixed experimental plot over the years has resulted in steady decrease in yield over the years (Table 2). In spent wash treatment applied @ 1 ½ NSW, during 2004 wheat grain yield was 25.8 q. h^{-1} and was reduced to 20.9 h^{-1} during 2013. Similar trend was also noticed with other spent wash treated plots treatment indicating continuous use spent wash may affect soil fertility. When fertilizer was applied more than the recommended dose (1 ½ NF), initial yield was 27.2 q. h^{-1} and was reduced to 19.7 q. h^{-1} during 2013. Decreasing trend in yield level was attributed to excess use of fertilizer and continuous use of same crop over the fixed plots over the years. Combination of treated spent wash and fertilizer was also failed to increase the yield over the years. However, when compared to farmers method of practice, yield levels over the years remain same.

Increase in biomass was also possible due to application of spent wash both at the equivalent of chemical fertilizer and higher level. Wherever spent wash substituted chemical fertilizer, wheat crop remained much greener and healthier. This significantly contributed for the total biomass of the crop. Crop nutrition with only fertilizer, on the contrary, recorded significantly lower biomass yield.

Table 1
Characteristics of spent wash (secondary treated)

Parameter	*Content*
Colour	Dark Brown
Odour	Bad
Temp (°C) at sampling	22-24
pH	8.3
EC (dS/m)	18.0
BOD (mg/l)	5360
COD (mg/l)	16000
TS (%)	4.15
TDS (%)	3.30
SS (%)	0.80
Cl (mg/l)	5105
Na (mg/l)	130
K_2O (mg/l)	5940
Ca (mg/l)	1920
Mg (mg/l)	720
Total N (%)	0.09
Total P_2O_5 (mg/l)	153
Zn (mg/l)	17.50
Fe (mg/l)	69.46
Mn (mg/l)	10.01

Higher biomass and grain yield during initial years with the application of treated spent wash in other crops have been reported by several workers (Bucknall *et al.,* 1979, Shailendranath & Rao, 1979 and Pathak *et al.,* 1999).

Higher grain and biomass yield with spent wash application could be attributed to the contribution of nutrients from it (Table 2). Controlled mineralization of the soil organic matter under spent wash applied plots made steady availability of nutrients to the crop. This was further confirmed in the mixed mode of application. A reduction in the level of spent wash application reduced growth and yield and latter's attributes. Silva *et al.* (1981) and Viera (1982) reported improved growth and yield parameters in sugarcane with the treated spent wash irrigation.

Effect on soil properties: continuous use of spent wash has affected conductivity of soil (Table 3). Conductivity of treated spent wash was remained higher (18.0 dS/m), and continuous use has shown increase in conductivity of soil. In the year 2003 soil conductivity was 0.96 dS/m and it was increased to 3.52 dS/m in spent was treated plots indicating continuous was no good for soil health and productivity.

Table 2
Effect of long-term application of treated distillery spent wash on Wheat yield

	Yield (q/ha) over the years									
Treatments	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
T1 – INSW	25.6	25.5	24.4	23.9	22.9	22.1	23.4	20.6	21.4	20.5
T2 – 1 ½ NSW	25.8	28.5	27.4	27.7	25.4	23.9	23.5	21.1	21.8	20.9
T3 – INF	27.5	29.7	28.6	23.2	23.9	23.1	22.9	20.5	21.3	20.4
T4 1 ½ NF	27.2	27.9	27.1	25.4	24.7	23.6	23.2	20.5	21.2	19.7
T5 – ½ NF + ½ NSW	23.8	28.4	27.3	21.2	21.5	21.0	20.2	17.2	18.3	17.0
T6 – ½ NSW + ½ NF	23.6	29.0	27.9	21.3	21.9	20.9	20.1	17.4	18.1	16.7
T7 – FP	16.6	25.5	24.4	21.2	20.9	20.1	21.3	17.6	18.0	16.2
S.E.m. ±	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
CD (0.05)	1.0	1.1	1.2	1.3	1.1	1.1	0.8	1.0	0.8	0.8

Table 3
Effect of long-term application of treated distillery spent wash on electrical conductivity of soil (dS/m)

Ece	*Years*									
Treatments	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
T1 – INSW	1.25	1.36	1.41	1.96	2.11	2.32	2.56	2.89	3.09	3.19
T2 – 1 ½ NSW	1.32	1.60	1.59	2.20	2.57	2.80	3.04	3.33	3.45	3.52
T3 – INF	0.83	0.99	1.04	1.55	1.63	1.63	1.63	1.73	1.77	1.88
T4 1 ½ NF	0.89	1.04	1.09	1.48	1.56	1.60	1.60	1.65	1.64	1.77
T5 – ½ NF + ½ NSW	1.05	1.20	1.20	1.75	1.99	2.08	2.20	2.53	2.59	2.80
T6 – ½ NSW + ½ NF	1.00	1.25	1.35	1.77	1.93	1.99	2.13	2.45	2.57	2.67
T7 – FP	0.85	0.93	1.03	1.51	1.55	1.57	1.57	1.68	1.73	1.84
S.E.m. ±	0.09	0.10	0.10	0.11	0.09	0.10	0.10	0.09	0.11	0.09
CD (0.05)	0.27	0.32	0.30	0.33	0.27	0.29	0.31	0.29	0.32	0.26

Similar trend was also noticed with potassium accumulation soil in spent wash treatments (Table 4).

Table 4
Effect of long-term application of treated distillery spent wash on potassium in soil (Kg.h^{-1})

Available soil potassium (kg/ha)	*Years*									
Treatments	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
T1 – INSW	620.0	731.0	726.1	835.6	1019.7	1402.8	1582.2	1639.0	1664.4	1782.9
T2 – 1 ½ NSW	639.0	789.0	761.6	912.8	1251.2	1635.6	1802.7	1842.5	1882.9	1928.7
T3 – INF	631.0	350.0	406.6	457.8	527.7	634.1	720.5	725.9	738.9	755.3
T4 1 ½ NF	359.0	360.0	425.6	451.2	522.0	631.4	717.8	714.2	732.3	758.0
T5 – ½ NF + ½ NSW	410.0	486.0	509.1	626.3	776.9	1061.5	1196.1	1230.7	1235.3	1279.9
T6 – ½ NSW + ½ NF	430.0	530.0	535.1	632.3	830.2	1112.5	1229.4	1284.0	1294.9	1333.2
T7 – FP	320.0	317.0	411.6	476.8	555.4	654.2	724.3	735.8	759.3	759.4
S.E.m. ±	4.0	1.3	1.7	1.6	2.4	2.3	2.4	2.4	3.0	3.2
CD (0.05)	12.1	4.0	5.1	4.7	7.3	7.0	7.3	7.1	9.1	9.6

Based on the results, it could be concluded that treated distillery spent wash should not be used in agriculture continuously as a source of plant nutrients which may adversely effect soil health. However, studies on optimum dosage, time of application and method of application of spent wash for different crops need to be assessed along with its long-term effects on growth, yield and quality of crops, soil health and ground water quality.

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