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# Effect of Distillery Spent-wash on Channel Bed and Groundwater Quality: Case Study of Unicol Distillery District Mirpurkhas

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***Abstract***— *The effect of treated spent wash on channel bed and groundwater qualities was investigated during 2014-15 at Unicol distillery as study area in district Mirpurkhas. For this purpose, samples of spent wash, soil/water were collected and determined for parameters related to physical and chemical properties. The impact of spent wash on channel bed and on the adjacent soils at different distances showed that highest soil EC (18.40 dS m-1) and TDS (11776 ppm) were determined for spent wash channel bed at surface soil and EC decreased with increasing distance from channel bed at sub-surface layers; while the highest overall soil pH (7.43) was observed at 450m distance at 30-45 cm soil depth. The highest total N (0.16%) and available K (0.53%) was observed at channel bed and at surface soil with highest available P (4.80%) at channel bed in sub-surface (15-30 cm) soil. The groundwater samples obtained from tube well and hand pump were also analysed for physical and chemical properties and compared with the spent wash from channel bed. The lower Na (1578.7 ppm) was determined in hand pump water samples than tube well water (2588.3 ppm); while highest (7050 ppm) in spent wash. The $HCO_3$ was lower in tube well water (247.00 ppm) than hand pump water (430 ppm); and highest (6166.70 ppm) in spent wash. The Chloride (Cl) content was lower (2117 ppm) in hand pump water samples than tube well water (5259 ppm); and highest in spent wash (14097 ppm). The groundwater EC was lower (11.077 dS m-1) hand pump water than tube well water (17.262 dS m-1) and highest (47.090 dS m-1) in spent wash. Similarly, the lower magnesium (465.3 ppm) was determined in hand pump water samples than tube well water (553.3 ppm) and exceptionally high (1300.7 ppm) in spent wash. The SAR of hand pump water samples was lower (11.583) than tube well water (20.390) and outstandingly high (35.693) for spent wash. In case of calcium content, it was lower in tube well water (359.33 ppm) than hand pump water (593.33 ppm) and exceptionally higher in spent wash (764.33 ppm). It was concluded that soil EC and TDS were lower at farther locations from spent wash channel bed at sub-soils. The surface soil contained higher organic matter; no effect of spent wash on soil organic matter was recorded. The soil pH was relatively higher at spent wash channel bed and its adverse effects were noted upto 300-meter distance. Total N was slightly (P>0.05) higher at channel bed than distant locations, while phosphorus was significantly higher at spent wash channel bed. The available potassium was also significantly influenced by the spent wash; and P was higher at channel bed, and decreased at the farther locations adjacent to the channel bed. The EC level, Na, HCO3, Cl, Mg and Ca contents as well as SAR for spent wash samples were manifold higher than the tube well and hand pump water samples.*

***Keywords***— ***spent-wash, hand pumps, tube wells, ground water quality, drainage channel bed quality.***

## I. INTRODUCTION

One of the most important environmental problems faced by the world is management of wastes. Different industries create a variety of wastewater pollutants; which are difficult and costly to treat. Wastewater characteristics and levels of pollutants vary significantly from industry to industry [1~4]. The Effluent draining from distillery industries during the production of ethanol is considered as a major source of the environmental pollution. Distillery spent wash is considered as one of the big issues of pollution. This is because this effluent has extremely high values of chemical oxygen demand (COD), biological oxygen demand (BOD), inorganic solids, and low pH [5 & 6]. Basically, distillery spent wash industries are the agro-based industries and their waste effluent having high organic and inorganic compounds which are high strength based and difficult to disposed [7]. A typical cane molasses-based distillery generates 15 liters of spent wash per liter of ethanol produced [8]. This dark brown spent wash is being overloaded with high organic nitrogen, high organic and inorganic salts as a result having high electrical conductivity (EC) causes depletion of oxygen and produces bad smell [9~11]. Removal of distillery effluent on land is similarly harmful for the vegetative cover. It is described to reduce soil alkalinity and manganese availability, thus hindering seed germination defined by Kumar et al., [11].

Improper use of distillery effluent on soil without any suitable monitoring and checking, harmfully impacts the groundwater quality changing its physicochemical properties such as color, pH, electric conductivity (EC), through of leaching down of its organic and inorganic ions [13]. Due to high amount of salts in spent wash, soil can become sodic, saline, contaminated with a wide range of chemicals. Spent wash has high sodium content and when it is allowed to flow on land it causes negative impacts on soil properties [14 & 15]. This waste effluent may infiltrate into the sub-soil and put bad impacts on the ground water [16]. The discarding of huge quantities of biodegradable waste without systematic management, results in significant environmental pollution [17 & 18].

The spent wash contains high organic and inorganic contents which are high strength wastes and difficult to dispose [19] create a great destruction of natural and human resources [20]. Cane molasses also contains trace amount of dark brown pigment called melanoidins that impart color to the spent wash generated at the temperature range of 71-800C [21]. Distillery industry which produces a huge amount of wastewater is highly polluted and has very high chemical and biological oxygen demand (COD and BOD), heavy loaded of organic matter is dark brown reddish in color with unpleasant odour of indole, sketol and other sulpher compounds [22~24]. The research reports indicate that the spent wash contains heavy metals e.g. Hg, Cd, Cr which can accumulate and enter in food chain and biomagnifies to toxic level [25]. Germination percentage decreases with the concentration of effluent and put bad effect on livestock as well as Farmer's health and soil fertility; due to the effluent, groundwater qualities also deteriorated day by day [4, 26 ~28].

Ahmed et al. [29] assessed environmental impact of distilleries on soil quality. Research work is an experimental comparative study. Three locations were selected in Sindh Province of Pakistan among two were considered polluted and one was unpolluted or controlled site and controlled sample was taken from Sujawal City. Soil samples were taken as vertically and horizontally from and around distilleries. Spent wash samples were taken from the first two locations. Analytical assessment shown soil samples exceeded the limits those of the control soil samples, like pH of Mirpurkhas location surface soil 6.2 to 8.1, EC 308 µS/cm to 4.50 mS/cm, salinity 0.5%o to 2.4%o, T.N 24.8mg/l to 47.9mg/l, T.K 249.7mg/l to 291.5mg/l, T.P 0.29mg/l to 4.18mg/l, T.H 529mg/l to 1120mg/l, T.C 305mg/l to 690mg/l, S 71 mg/l to 101mg/l and Cl 27mg/l to 34.9mg/l and vertical soil of Mirpurkhas having pH 7.6 to 8.03, EC 221µS/cm to 725µS/cm, salinity 0.1%o to 0.4%o, T.N 32.7 mg/l to 49.8mg/l, T.P 0.26mg/l to 1.29mg/l, T.K 217.6 mg/l to 298.6mg/l, T.H 450mg/l to 1030mg/l, T.C 217mg/l to 630mg/l, S 65mg/l to 118mg/l and Cl 23.4mg/l to 39.3 mg/l, and deep soil having pH 7.9 to 8.30, EC 240µS/cm to 713µS/cm, salinity 0.2%o to 0.4%o, T.N 32.6 mg/l to 51.8mg/l, T.P 1.22 mg/l to 1.98 mg/l, T.K 264.2mg/l to 293.7mg/l, T.H 400 mg/l to 890mg/l, T.C 270mg/l to 450mg/l, S 67mg/l to 113mg/l and Cl 21mg/l to 35.2mg/l). Similarly, spent wash samples also exceeding the National Environmental Quality Standards limits.

## II. MATERIALS AND METHODS

The study was carried out to evaluate the effect of treated spent wash on channel bed and groundwater qualities in district Mirpurkhas Unicol distillery. For this purpose, samples of spent wash, soil and water were collected.

**Sample collection**

Spent wash sample were collected in a clean glass container (the lid, seal and bottle were raised with boiling water before use) from outlets of Unicol distillery from MirpurKhas. The clean sterilized containers with stoppers were filled with the respective sample materials leaving one fourth of the containers empty. The samples were labeled properly and stored in ice box at 4°C and brought to the laboratory at the Centre of Excellence in Analytical Chemistry, University of Sindh Jamshoro. Standard procedures for chemical analysis of sample were used.

The Following parameters were determined for detailed analysis of the soil in surroundings of the spent wash channel bed.

EC (dS/m-1), TDS (%), Organic matter (%), pH

Nitrogen (%), Phosphorus (ppm), Potassium (%)

The water samples from different sources such as tube wells and hand pumps were also collected from the surroundings of the spent wash channel bed and their determinations were compared with spent wash. The collected water samples were labeled properly and brought to the laboratory at the Centre of Excellence in Analytical Chemistry, University of Sindh Jamshoro. Standard procedures for chemical analysis of sample were used.

The Following parameters were determined for detailed analysis of the water in comparison with spent wash.

| S. # | Determinations | Method |
|---|---|---|
| 1. | Na (ppm) | Flame Photometer (Jenway UK Model No. PFP-7) |
| 2. | CO3 and HCO3 (ppm) | By titration with standard sulfuric acid (H2SO4) using phenolphthalein and methyl orange indicators respectively |
| 3. | Cl (ppm) | titrating against standard silver nitrate (AgNO3) solution using potassium chromate (K2CrO4) indicator |
| 4. | EC (dS/m-1) | portable conductivity meter (Hana Model-8733, Germany) |
| 5. | Calcium and Magnesium (ppm) | titrating with std. versinate EDTA in the presence of NH4Cl+NH4OH buffer solution and Eriochrome Black T indicator |
| 6. | Residual sodium carbonate (RSC) | RSC = (CO32- + HCO3-) - (Ca2+ + Mg2+) (Rowell, 1994) |
| 7. | SAR [30] | $SAR = \frac{Na+}{[(Ca+2+Mg+2)/2]1/2}$ |
| 8. | Organic Matter | Walky and Black method [31] |
| 9. | pH | portable pH meter (Orion-ISE Model-SA-720 USA) |
| 10. | Total Nitrogen | Kjeldahl's apparatus [32] |
| 11. | Available Phosphorus | Spectrophotometer (Model Specord-200 PC. Analytik Jen, Germany) |
| 12. | Potassium | Flame Photometer (Jenway UK Model No. PFP-7) |

## III. RESULTS AND DISCUSSION

The study embodied in this thesis was carried out to investigate the effect of treated spent wash on channel bed and groundwater qualities in district Mirpurkhas Unicol distillery during the year 2015. For this purpose, samples of spent wash, soil/water were collected and determined for parameters related to physical and chemical properties.

The findings of the study showed that soil EC and TDS were lower at farther locations from spent wash channel bed at sub-soils. The surface soil contained higher organic matter; no effect of spent wash on soil organic matter was recorded. The soil pH was relatively higher at spent wash channel bed and its adverse effects were noted upto 300 meter distance. Total N was slightly ($P>0.05$) higher at channel bed than distant locations, while phosphorus was significantly higher at spent wash channel bed. The available potassium was also significantly influenced by the spent wash; and P was higher at channel bed, and decreased at the farther locations adjacent to the channel bed. The EC level, Na, HCO3, Cl, Mg and Ca contents as well as SAR for spent wash samples were manifold higher than the tube well and hand pump water samples. The present results are consolidately in agreement with many past researchers. Somawanshi and Yadav [33] indicated that additions of dilute spent wash would not add soluble salts to the soil provided there was sufficient leaching of soil solution. However, additions of concentrated spent wash would result in increased salinity of both soil and groundwater. Zalawadia et al. [34] observed increased P, K and S there by indicating the signs of improvement in soil properties. An increase in the soil available N, P and K by pre-sowing irrigation with distillery was noticed. The highest value of soil organic carbon (0.7%) was found in 87.5 m3/ha spent wash level. The available N, P and K content (216, 8.89 and 5488 kg/ha, respectively) of soil increased with an increase in spent wash levels. Baskar et al. [35] concluded that distillery effluent a waste water of distillery industry is of purely plant origin and contains large quantities of soluble organic matter and plant nutrients. Spentwash helped in better nutrition as it also supplemented micronutrients. It did not suppress biological activity and no significant changes were observed in them due to spentwash use. Diagan et al. [4] observed concentration of effluent spent wash depleted the groundwater quality. Kalaiselvi and Mahimairaja [8] concluded that the spent wash treated soil is enriched with the plant nutrients such as nitrogen, phosphorus and potassium. Chandraju et al. [36] concluded that diluted spentwash can be conveniently used for cultivation of leafy vegetables. Kanimozhi and Vasudeven [25] indicated that the spent wash contains heavy metals. Shenbagavalli et al. [37] reported that more than 50% of the samples were found unsuitable for irrigation purpose as they have shown greater potential for salinity hazards. Though no marked evidence was observed on the soil characteristics, the nutrients (N, P and K) and salt (Na, Ca, Mg, Cl and SO4) contents were relatively higher in these soils previously amended with the spentwash. Rakhi Chaudhary and Mahima Arora [27] reported soil and groundwater pollution due to spent wash channels. Mahar et al. [38] reported that spent wash has adversely affected the soil and groundwater parameters including pH, electrical conductivity, total dissolved solids (TDS), total hardness, chlorides, phosphates, alkalinity, nitrates, sulphates, chemical oxygen demand (COD), Na, K, Ca and Mg. Ajay et al. [28] argued that characteristics of spent wash do not allow its discharge into a water body; hence it requires treatment and dilution before discharge. Ansari et al. [11] conducted argued that spent wash requires treatment and dilution before discharge. Effluent originating from distilleries known as spent wash leads to extensive water pollution. Chandrakant and Kedar [39] considered spent wash as an ecotoxic effluent. Jha et al. [40] concluded that application of spent wash brings significant improvement in soil fertility and enhances the productivity of sugarcane in calcareous soil. Latha et al. [41] found that application of spent wash not only adds mineral N and carbon to soil, but also promotes the mineralization of soil organic C and N, thus resulting in large amounts of carbon, NH4 -N and NO3 -N in soil. Khandegar and Saroh [42] indicated that spent wash, leads to extensive soil and water pollution. Anoop and Renu [43] determined the impacts of sugar industry on ground water quality of area around the sugar industry. In villages, town and cities most of the population totally depend on the ground water for drinking purposes, domestic as well as for agriculture use, hence quality of ground water is extremely essential and must be analyzed. Ahmed et al. [29] took spent wash samples and shown soil samples exceeded the limits those of the control soil samples, like pH of Mirpurkhas location surface soil 6.2 to 8.1, EC 308 µS/cm to 4.50 mS/cm, salinity 0.5‰ to 2.4‰, T.N 24.8mg/l to 47.9mg/l, T.K 249.7mg/l to 291.5mg/l, T.P 0.29mg/l to 4.18mg/l, T.H 529mg/l to 1120mg/l, T.C 305mg/l to 690mg/l, S 71 mg/l to 101mg/l and Cl 27mg/l to 34.9mg/l and vertical soil of Mirpurkhas having pH 7.6 to 8.03, EC 221µS/cm to 725µS/cm, salinity 0.1‰ to 0.4‰, T.N 32.7 mg/l to 49.8mg/l, T.P 0.26mg/l to 1.29mg/l, T.K 217.6 mg/l to 298.6mg/l, T.H 450mg/l to 1030mg/l, T.C 217mg/l to 630mg/l, S 65mg/l to 118mg/l and Cl 23.4mg/l to 39.3 mg/l, and deep soil having pH 7.9 to 8.30, EC 240µS/cm to 713µS/cm, salinity 0.2‰ to 0.4‰, T.N 32.6 mg/l to 51.8mg/l, T.P 1.22 mg/l to 1.98 mg/l, T.K 264.2mg/l to 293.7mg/l, T.H 400 mg/l to 890mg/l, T.C 270mg/l to 450mg/l, S 67mg/l to 113mg/l and Cl 21mg/l to 35.2mg/l). Similarly, spent wash samples also exceeding the National Environmental Quality Standards limits.

**Electrical conductivity (EC dSm-1)**

Soil samples were taken from the spent wash channel bed at varied distances (00, 150, 300, 450m) from outlet and determined for electrical conductivity at the soil depths 0-15, 15-30 and 30-45 cm. The data (Figure -1) showed that surface soil (0-15 cm) contained higher average EC level of 17.81 dSm-1, followed by EC levels of 14.89 dSm-1 and 12.91 dSm-1 at 15-30 and 30-45 cm soil depths, respectively. The effect of spent wash on EC level at different distance from spent wash channel bed indicated that at outlet, the EC level was highest (15.78 dS m-1); while the EC level of the soil significantly decreased to 15.35, 15.07 and 14.62 dS $m^{-1}$ with increasing the distance from spent wash channel bed to 150, 300 and 450 meters, respectively.

The highest overall soil EC was determined for the soil samples obtained from spent wash channel bed at surface soil (18.40 dS m-1); while the lowest (12.43 dS m-1) in the samples obtained from the location at 450 meter distance from spent wash channel bed. There were significant ($P<0.05$) decrease in the EC level with increasing soil depth and increasing the distance from the spent wash channel bed.

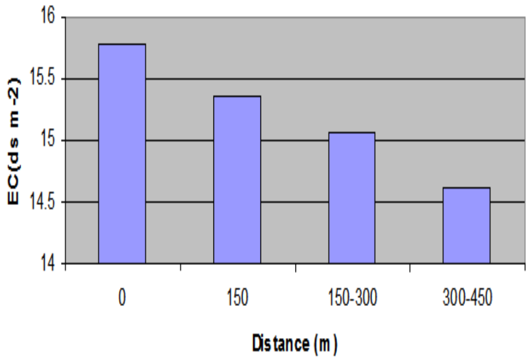



*Fig.1: Soil EC (dS m$^{-2}$) at various distances from the spent wash channel bed*

**TDS (ppm)**

The soil samples (0-15, 15-30 and 30-45 cm) were obtained from the spent wash channel bed and at varied distances (00, 150, 300, 450m) were examined for TDS. The data (Figure 2) indicated that the surface soil (0-15 cm) contained highest average TDS level of 10903 ppm, followed by 8863 and 8318 ppm TDS levels at 15-30 and 30-45 cm soil depths, respectively. The effect of spent wash on TDS level at different distance from spent wash channel bed showed that at channel bed, the TDS level was highest (10097 ppm); while the TDS level in soil markedly reduced to 9635, 9053 and 8660 ppm with increase in distance from outlet in spent wash channel bed to 00, 150, 300 and 450 meters, respectively. The highest overall TDS contents were noted in soil samples obtained from channel bed at surface soil (11776 ppm); while the lowest (7872 ppm) in the samples obtained from at location 450 meter distance from spent wash channel bed. There were significant ($P<0.05$) decrease in the TDS level with increasing soil depth and the TDS was higher in the soils closer to the spent wash channel bed.

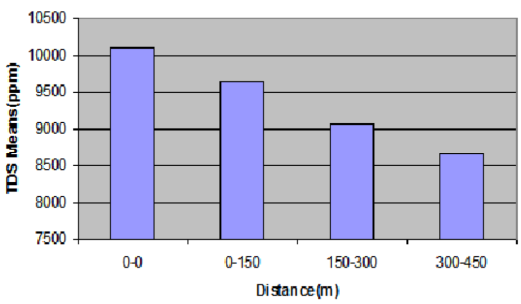



*Fig.2: TDS in soil (ppm) at various distances from the spent wash outlet in the channel bed*

**Organic matter (%)**

Soil organic matter is the most important element that influences the soil productivity; and soil amendments are mainly considered first to improve the soil organic matter. The soil samples at 0-15, 15-30 and 30-45 cm depths were collected from the channel bed as well as at varied distance from outlet of spent wash channel for examining the soil organic matter. The data (Figure 3) exhibited that the surface soil (0-15 cm) contained markedly highest organic matter (2.21%), while the soil organic matter declined to 0.81 percent and 0.65 percent at 15-30 and 30-45 cm soil depths, respectively. The effect of spent wash on soil organic matter at varied distance from spent wash channel bed showed that at channel bed, the soil organic matter was relatively higher (1.27%) as compared to 150, 300 and 450 meter distance from spent wash channel bed with average soil organic matter contents of 1.22, 1.21 and 1.19 percent, respectively. The highest overall soil organic matter (2.32%) was noted at channel bed near outlet; while the lowest soil organic matter (0.64%) was equally observed at 300 and 450 meter distance from spent wash channel bed in the 30-45 cm soil depth. The statistical analysis suggested significant effect of soil depth on soil organic matter ($P<0.05$); while the effect of spent wash at channel bed and at different distances from the outlet was statistically non-significant ($P>0.05$). This indicates that the surface soil always contained higher organic matter as compared to sub-surface layers; but the spent wash did not show a significant impact on the soil so far the soil organic matter is concerned.

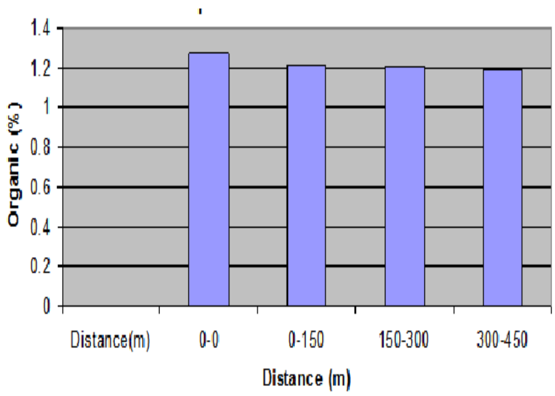



*Fig.3: Organic matter in soil (%) at various distances from the spent wash channel bed*

**Soil pH**

Soil pH is a key factor to influence the crop productivity and pH generally has close association with the soil EC. The soil samples at 0-15, 15-30 and 30-45 cm depths were achieved from the spent wash channel bed and at four distances from outlet for determining the soil pH. The data (Figure 4) described that the soil pH was highest at the surface soil (0-15 cm) with pH value of 7.39, and the soil pH decreased to 7.20 and 7.18 at 15-30 and 30-45 cm soil depths, respectively. The effect of spent wash on soil pH at varied distances from outlet of spent wash channel showed that near outlet the channel bed as well as at 150 meter distance, the soil pH was equally higher (7.32) as compared to 300 and 450 meter distance from outlet in spent wash channel bed with average soil pH of 7.27 and 7.10, respectively. The highest overall soil pH (7.43) was observed at 450 meter distance from channel bed at 30-45 cm soil layer; while the lowest soil pH (7.00) was equally observed at channel bed in surface (0-15 cm) and sub-surface (30-45 cm) soils. The statistical analysis suggested significant effect of soil depth and spent wash on soil pH ($P<0.05$). However, similarity in soil pH was observed for 0, 150 and 300 meter distances from channel bed ($P>0.05$); as well as for 15-30 and 30-45 cm soil depths ($P>0.05$). This indicates that spent wash channel has some adverse effects on the soil upto 300 meter distance.

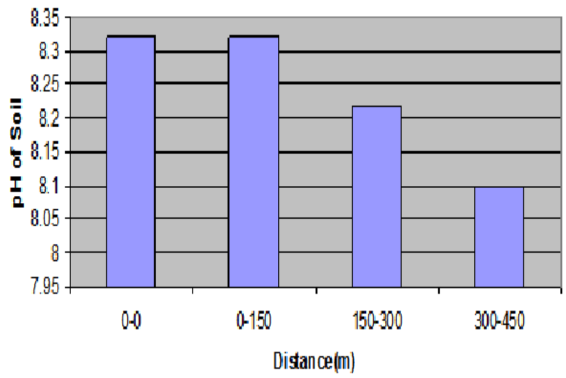



*Fig.4: pH of soil at various distances from the spent wash channel bed*

**Total N in soil (%)**

Nitrogen is the key element required by the plant for growth and without nitrogen crop production is rather impossible. The soil samples at 0-15, 15-30 and 30-45 cm depths at the experimental sit were obtained from the spent wash channel bed and at four distances from channel outlet for determining the total N. The data (Figure 5) showed that the total N was remarkably higher (0.148%) at the surface soil (0-15 cm), and N declined to 0.071 and 0.062 percent at 15-30 and 30-45 cm soil depths, respectively. The effect of spent wash on total N at progressive distances from outlet of channel showed that at zero and at 150 meter distance, the total N was higher i.e. 0.099 and 0.098% as compared to 300 and 450 meter distance from channel bed with average total N of 0.091 and 0.086 percent, respectively. The highest overall total N (0.16%) was observed at channel bed and 150 meter distance from channel bed at 0-15 cm soil layer; while the lowest total N (0.060%) was observed at 450 meters distance from channel bed at 30-45 cm soil layer. Statistically, the effect of spent wash on total N on the soil was non-significant ($P>0.05$); while significant ($P<0.05$) between the soil depths. The similarity ($P>0.05$) in total N was observed for 15-30 and 30-45 cm soil depths. Although, there was bit increase in total N at the channel bed over the distant locations, but the differences were negligible for spent wash effects; while sub-surface layers were lower in total N as compared to the surface soil at the studied location.

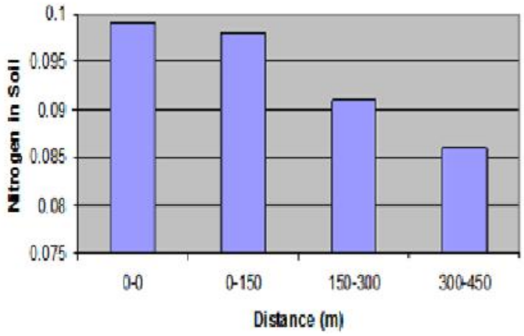



*Fig.5: Soil Nitrogen (%) at various distances from the spent wash channel bed*

**Available P in soil (%)**

Phosphorus is one of the essential elements required in the soil for plant growth and development. The effect of spent wash channel bed on the soil available P at different depths and distances was investigated. The data (Figure 6) indicated that the available P was remarkably higher (3.145%) at the surface soil (0-15 cm), and available P declined to 1.943 and 1.428 percent at 15-30 and 30-45 cm soil depths, respectively. The effect of spent wash on available P at progressive distances from channel bed indicated that at the channel bed, the available P was highest (3.60%) while available P simultaneously decreased to 2.23, 1.51 and 1.35% with increasing distance from channel bed to 150, 300 and 450 meters, respectively. The highest overall available P (4.80%) was noted at channel bed in 15-30 cm soil layer; while the lowest available P (1.01%) was recorded at 450 meters distance from channel bed in surface soil. Statistically, the differences in available P at various soil depths as well as the effect of spent wash channel bed at different distances was significant ($P<0.05$). However, similarity ($P>0.05$) in available P was recorded between 150, 300 and 450 meters distances as well as between 15-30 and 30-45 cm soil depths.

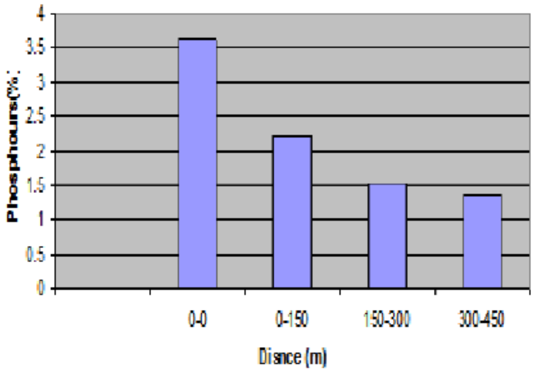



*Fig.6: Available phosphorus in soil (%) at various distances from the spent wash channel bed*

### Available K in soil (%)

Potassium (K) is another element that required in the soil essentially for plant growth and development. The available K was determined at the experimental site at the 0-15, 15-30 and 30-45 cm soil depths to see the effect of spent wash channel bed on the soil available K at adjacent area. The data (Figure 7) showed that the available K was higher (0.49%) in the surface soil (0-15 cm), and declined to 0.22 and 0.14 percent at 15-30 and 30-45 cm soil depths, respectively. The effect of spent wash on soil available K indicated that at the channel bed, the available K was highest (0.31%), while available K showed a concurrent decrease to 0.28, 0.27 and 0.26% with increasing distance from channel bed to 150, 300 and 450 meters, respectively. The highest overall available K (0.53%) was noted at channel bed in surface soil; while the lowest available K (0.13%) was determined at 300 meters distance from channel bed in sub-surface soil (15-30 cm). Statistically, the differences in available K at various soil depths as well as the effect of spent wash channel bed at different distances were significant ($P<0.05$). However, similarity ($P>0.05$) in available K was observed between 300 and 450 meters distances from channel bed.

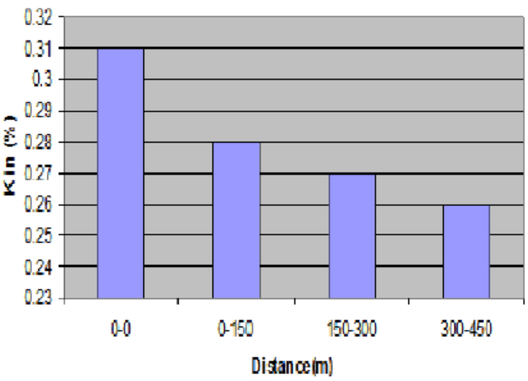



*Fig.7: Available potassium in soil (%) at various distances from the spent wash channel bed*

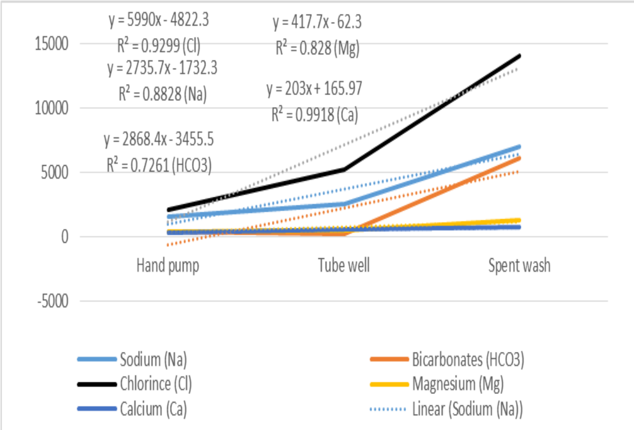
### Comparative analysis of groundwater and spent wash

The groundwater samples were collected from two sources (tube well and hand pump) and their physical and chemical properties were compared with the spent wash samples collected from the channel bed.

### Sodium (Na)

### BOD, COD and pH removal

The regression analsyis for reedgrass plant height v/s effulent quality suggested that 56.63% variation in BOD ($r^2 = 0.5663$), 51.32% variation in COD ($r^2 = 0.5132$) and 67.49% change in pH ($r^2 = 0.6749$) was guided by the change in the reed grass plant height.




The sodium (Na) concentration in groundwater samples collected from different sources was determined and compared with spent wash. The data (Figure 8) showed that the lowest Na concentration (1578.7 ppm) was determined in groundwater samples collected from hand pumps; and the Na concentration in tube well water was 2588.3 ppm; while the highest Na concentration (7050 ppm) was determined in spent wash. The above figure for Na concentrations in analysed liquid showed a highly significant difference and clearly indicated that the Na concentration in spent wash samples is manifold higher than the tube well and hand pump water samples.

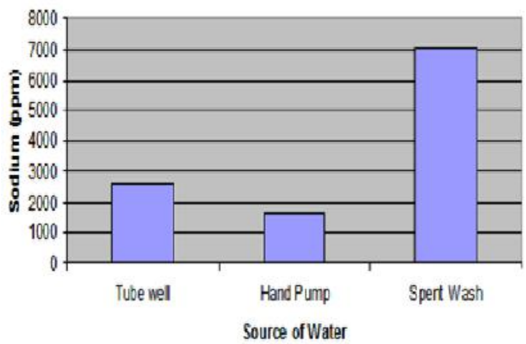



*Fig.8: Groundwater analysis for Na (ppm) obtained from different water sources as compared to spent wash channel bed*

**Bicarbonate ($HCO_3$)**

The bicarbonate (HCO3) concentration in groundwater samples collected from different sources was examined and compared with spent wash. The data (Figure 9) indicated that the lowest HCO3 concentration (247.00 ppm) was determined in groundwater samples collected from tube well; and the HCO3 concentration in hand pump water was 430.00 ppm; while the highest HCO3 concentration (6166.70 ppm) was determined in spent wash. The above data on HCO3 concentrations in analyzed water and spent wash samples showed a highly significant difference and concluded that the HCO3 concentration in spent wash samples was exceptionally higher than the water samples regardless the source of water. Moreover, differences in bicarbonate concentration between tube well and hand pump waters was also significant ($P<0.05$) showing that bicarbonate concentration in deep waters is lesser than the shallow waters.

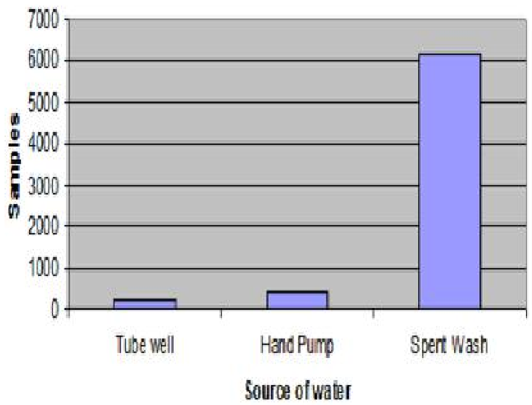



*Fig.9: Groundwater analysis for HCO3 obtained from different water sources as compared to spent wash channel bed*

**Chloride (Cl)**

The Chloride (Cl) content in groundwater samples collected from hand pumps and tube wells in surrounding areas of spent wash channel bed was determined and compared with chloride content of spent wash. The data (Figure 10) showed that the lowest chloride content (2117 ppm) was found in groundwater samples collected from hand pump; and the chloride content in tube well water was more than double to that of hand pump water (5259 ppm); while the highest chloride content (14097 ppm) was found in spent wash. This suggested that chloride quantities in spent wash are extraordinarily higher than the groundwater regardless the source of water. The differences in Chloride content between tube well and hand pump waters was also significant ($P<0.05$) indicated that the chloride content was higher in deep waters than the shallow waters.

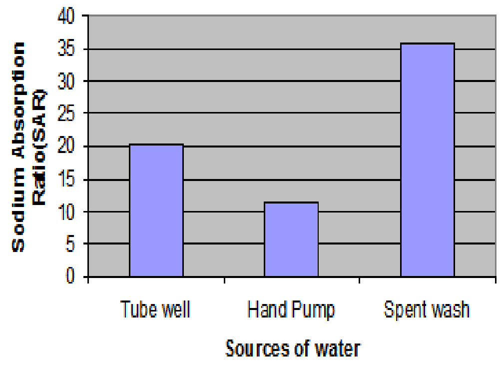



*Fig.10: Groundwater analysis for Cl (ppm) obtained from different water sources as compared to spent wash channel bed*

**Electrical conductivity (EC)**

The electrical conductivity (EC) level of groundwater samples collected from various sources such as tube well and hand pumps was determined and compared with spent wash. The data (Figure 11) indicated that the lowest EC level (11.077 dS m-1) was determined in groundwater samples collected from hand pumps; and the EC level in tube well water was relatively higher (17.262 dS m-1); while the alarmingly highest EC level (47.090 dS m-1) was determined in spent wash. This indicates that deep waters are of higher electrical conductivity as compared to that of shallow waters of hand pumps. However, spent wash was of huge level of electrical conductivity when compared with ground water irrespective of the source of water.

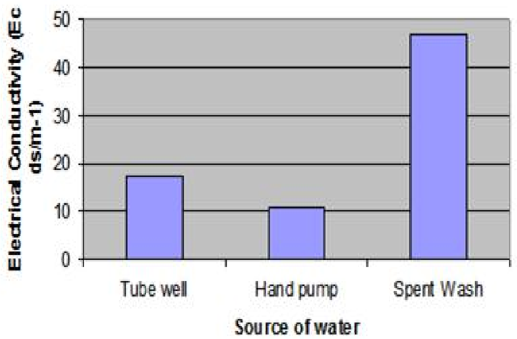



*Fig.11: Groundwater analysis for EC (dS/m) obtained from different water sources as compared to spent wash channel bed*

**Magnesium (Mg)**

The Magnesium content in groundwater samples collected from hand pumps and tube wells in surrounding areas of spent wash channel bed was examined and compared with magnesium content of spent wash. The data (Figure 12) exhibited that the lowest magnesium content (465.3 ppm) was determined in groundwater samples collected from hand pump; and the magnesium content in tube well water was significantly higher (553.3 ppm) than the water samples collected from hand pump water; while the exceptionally high magnesium content (1300.7 ppm) was recorded in spent wash. This suggested that magnesium quantities in spent wash were extremely higher than the groundwater samples apart from the source of water. The differences in Magnesium content between tube well and hand pump waters were also significant ($P<0.05$) indicated that the deeper water contained relatively higher magnesium contents as compared to shallow waters of hand pumps.

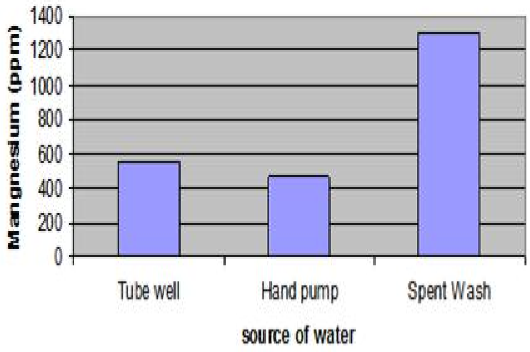



*Fig.12: Groundwater analysis for Magnesium (ppm) obtained from different water sources as compared to spent wash channel bed*

**Sodium absorption ratio (SAR)**

The sodium absorption ratio (SAR) of groundwater collected from hand pumps and tube wells in adjacent areas of spent wash channel bed was examined and compared with SAR of spent wash. The data (Figure 13) revealed that the lowest SAR (11.583) was analysed in groundwater samples collected from hand pump; and the SAR of tube well water was markedly higher (20.390) than the water samples collected from hand pump water; while the outstandingly high SAR (35.693) was analysed in spent wash. This suggested that SAR of spent wash was enormously higher than the groundwater samples and direct use of spent wash would not be useful. The differences in SAR for tube well and hand pump water were significant ($P<0.05$) indicated that the SAR was higher for deeper waters as compared to hand pumps.

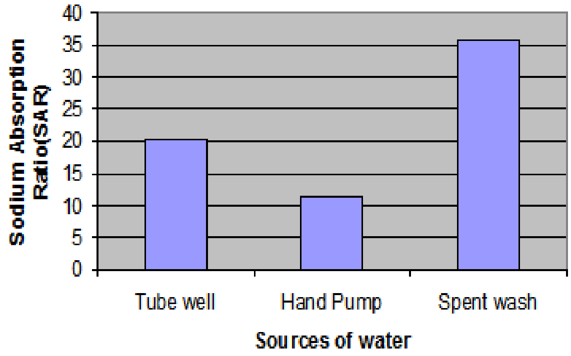



*Fig.13: Groundwater analysis for SAR obtained from different water sources as compared to spent wash channel bed*

**Calcium (Ca)**

The calcium content in groundwater of hand pumps and tube wells in the adjoining areas of spent wash channel bed was determined and compared with calcium content of spent wash. The data (Figure 14) indicated that the lowest calcium content (359.33 ppm) was observed in groundwater samples collected from tube well; and the calcium content in hand pump water was significantly higher (593.33 ppm) as compared to tube well water; while the spent wash contained superbly high (764.33 ppm). This indicated that calcium contents in spent wash were extremely higher than the groundwater samples apart from the source of water. The differences in calcium content between tube well and hand pump waters were also significant ($P<0.05$) indicated that the shallow water of hand pump contained significantly higher calcium as compared to deep waters of tube well. In view of the spent wash determination for calcium content, it is argued that without treatment of spent wash, its direct use would be harmful for the crops.

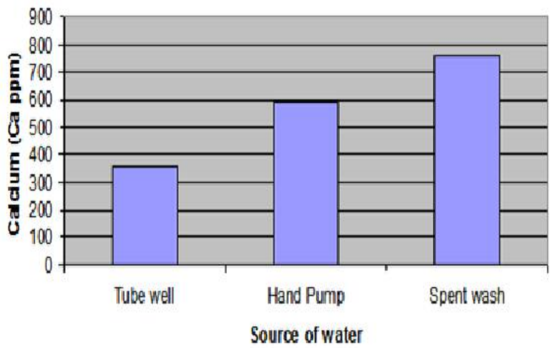



*Fig.14: Groundwater analysis for Calcium (ppm) content obtained from different water sources as compared to spent wash channel bed*

## IV. CONCLUSIONS

The soil EC and TDS were lower at sub-surface soil layers and at farther locations from the spent wash channel bed. The surface soil contained higher organic matter as compared to sub-surface layers; but the spent wash did not show a significant impact on the soil organic matter. The soil pH was relatively higher at spent wash channel bed and spent wash adversely affected the soil pH up to 300-meter distance. There was a marginal increase in total N at the channel bed over the distant locations, but the differences were negligible for spent wash effects; while sub-surface layers were lower in total N as compared to the surface soil. The phosphorus was significantly higher at spent wash channel bed, which increased simultaneously with increase in the distance from channel bed. The available potassium was also significantly influenced by the spent wash; and P was higher at channel bed and decreased at the farther locations adjacent to the channel bed. The EC level, Na, HCO3, Cl, Mg and Ca contents as well as SAR for spent wash samples were manifold higher than the tube well and hand pump water samples.

## REFERENCES

[1] Kuntal, M. H., A. K. Biswal, K. Bandyopdhayaya and K. Mishra. 2004. Effect of post methanation effluent on soil physical properties under a soyabean-Wheat system in a vertisol. Plant Nutri. & Soil Sci. 167(5): 584-590.

[2] Chakarbarty, R. N. 1980. Management of sugar and alcohol industry wastes-pollution control and conservation of energy and fertilizer. Proc. Symp. Disposal of sugar and distillery waste, U. P. Water pollution Control Board, Lucknow.

[3] Lin, Y. and S. Tanka. 2006. Ethonal fermentation from biomass resources: current state and prospects. App. Microbiol. Biotechnol, 69: 627-642.

[4] Diangan, J. M., T. Perez and R. Clveria. 2008. Analysis of land application as a method of disposal of distillery effluent. Int. J . Env. H. 2: 258-271.

[5] Shin, H. S.; Bae, B.U.; Lee, J. J.; Paik; B. C. (1992). Anaerobic digestion of distillery waste-water in a 2-phase UASB system. Water Science Technology; 25, 361-371.

[6] Saha, N. K.; Balakrishnan, M.; Batra, V. S.(2005). Improving Industrial Water Use: Case Study for an Indian Distillery. Res., Conserv. and Recyc.; 43, 163- 174. S

[7] Thakkar, A. (2013). Chemical Study on Distillery Effluent to Assess Pollution Load. Int. J. on Emerg. Tech.; 4, 121-123.

[8] Kalaiselvi, P and S. Mahimai Raja. 2009. Effect of bio-methanated spent wash on soil enzymatic activities. Bot. Res. Int.2 (4):267-272.

[9] Chauhan, A. (1991). Effect of distillery effluent on liver Wain Ganga, Indian J. Env. Hlth., 33, 203-207.

[10] Haroon, M. A. R.; Subash Chandra Bose, M. (2004). Use of distillery spent wash for alkali soil reclamation, treated distillery effluent for fertile irrigation of Crops. Indian Farm; March, 48-51. Oxford English Dictionary.

[11] Ansari, F., A.K. Awasthi and B.P. Srivastava. 2012. Physico-chemical characterization of distillery effluent and its dilution effect at different levels. Arch of App. Sci. Res, 4 (4): 1705-1715.

[12] Kumar, V.; Wati, L.; Fitz, F. G.; Nigam P.; Banat, I.M.; Singh, D.; Marchant, R. (1997a). "Bioremediation and de-colorization of an aerobically digested distillery spent wash", Biotech. Lett.;19, 311–313.

[13] Jain, R. K.; Kapur, M.; Labana, S.; Lal, B.; Sarma, P. M.; Bhattacharya, D.; Thakur, I. S. (2005). Microbial diversity: Application of microorganisms for biodegradation of xenobiotics. Current Science; 89, 101- 112.

[14] Christoph, M.; Theopisti, L.; Volker, J. D. (2001). Determination of Heavy Metals in Soils, Sediments and Geological Materials by ICP-AES and ICP-MS Mikrochim. Acta; 136, 123-128.

[15] Ramadura R., Gerard E. J. (1994). Distillery effluent and downstream products, SISSTA. Sugar Journal; 20,129-131.

[16] Akif, M.; Khan, A. R.; Sok, K. M.; Hussain, Z. M.; Abrar, K. M.; Muhammad, A. (2002). Textile Effluents and Their Contribution towards Aquatic Pollution in the Kabul River (Pakistan). Pak. J. Chem. 24, 106-111.

[17] Jain, N; Nanjundaswamy, C.; Minocha, A. K.; Verma, C. L. (2001). Indian journal of experimental biology; 39, 490-492.

[18] Pant, D.; Adholeya, A. (2007). Bio-resource technology; 98, 2321-2334.

[19] Billore, S.K., N. Singh, H.K. Ram, J.K. Sharma, V.P. Singh, R.M. Nelson and P. Dass. 2001. Treatment of molasses based distillery effluent in a constructed wetland in central India. Water Sci. and Tech. 44 (11-12): 441-448.

[20] Tao, F., J. Y. Miao, G. Y. Shi and K. C. Zhang. 2005. Ethanol fermentation by an acid-tolerant Zymomonas mobilis under non-sterlized condition. Process Biochemistry 40 (1): 183-187.

[21] Toma, M. M., U. Kalnenieks, A. Berzins, A. Vignts, M. Rikmnis and U. Viesturs. 2003. The effect of mixing on glcose fermentation by zymomonos mobilis continuous culture. Process Biochemistry, 38 (9) : 1347-1350.

[22] Nandy,T. S. Shasty and S. N. Kaul. 2002. Wastewater management in cane molasses distillery involving bioresources recovery. J. of Env. Management, 65 (1): 25-38.

[23] Uppal, J. 2004. Water utilization and effluent treatment in the indian alcohol industry: an overview. In: Tewari, P. K. (Ed), Liquid Asset, Proceedings of the Indo-EU workshop on promoting effluent water use in agro-based industries. TERI Press, New Delhi, India, Pp. 13-19.

[24] Yeoh, B. G. 1997. Two-phase anaerobic treatment of cane-molasses alcohol tillage. Water sci. and Technol. 36 (6-7) : 441-448.

[25] Kanimozhi, R. and Vasudevan, N. 2010. An over view of waste water treatment in distillery industry. Int. J. Env. Engi. 2: 159-184.

[26] Murugaragavan, R. 2002 Distillery spent wash on crop production in dry land soils. M. Sc (Environmental

Sciences) Thesis, Tamil Nadu Agricultural University, Coimbatore, India.

[27] Rakhi, C. and M. Arora. 2011. Study on distillery effluent: chemical analysis and impact on environment. Int. J. of Adv. Engg. Techno. II (II): 352-356.

[28] Ajay, F, A. F. Ansari and B.P. Srivastava. 2012 Physico-chemical characterization of distillery effluent and its dilution effect at different levels. Arch of App. Sci. Res, 1 (1/2): 29-37.

[29] Ahmed, M., J. Qureshi, Y. Nergis and M. Shareef. 2015. Environmental Impacts of Spent Wash on Soil Quality. Int. J. Econ. Environ. Geol. 6 (1) : 15-20.

[30] Rowell, D.L. 1994. Soil Science. Methods and Applications. Longman scientific & Technical, UK.

[31] Jackson, M. L. 1958a. *Soil Chemical Analysis*. 214-221.

[32] Jackson, M. L. 1958b. *Soil Chemical Analysis*. 498p. illus Englewood Cliffs, N.J.; Prentice-Hall, Inc. Kirk, P.L.

[33] Somawanshi, R. B. and A.M. Yadav. 1992. Effects of spent wash (distillery effluent) on soil chemical properties and composition of leachate. Proc. Ann. Con. of the Deccan Sug. Techn. Assoc. 1 : 101-108.

[34] Zalawadia, N.M., S. Raman and R.G. Patil, 1997. Influence of diluted spent wash of sugar Industries application on yield and nutrient uptake by sugarcane and changes in soil Properties. J. Indian Soc. Soil. Sci., 45: 767-769.

[35] Baskar, M., Kayalvizhi, C. and Bose, M.S.C. (2003) Ecofriendly utilization of distillery effluent in agriculture – A review. Agricultural Reviews 24, 16-30.

[36] Chandraju, S., R. Nagen draswamy, C. S. Chidan kumar and R. Venkat chalapathy. 2010. Nutritional additives of distillery Spent wash on the production of radish (Raphanous sativus), onion (Allium cepa) and garlic (Allium cepa) medicinal plants in normal and Spentwash Treated Soil. Bioresearch Bull 2: 59-65.

[37] Shenbagavalli. S., S. Mahimairaja and P. Kalaiselvi. 2011. Impact of biometha-nated distillery spentwash application on soil and water quality: A field appraisal. Int. J. Envir. Sci. 1 (7) : 1753-1758.

[38] Mahar, M.T., M.Y. Khuhawar, M.A. Baloch, T.M. Jahangir. 2012. Effects of spent wash of ethanol industry on groundwater: A case study of Rahimyar Khan District, Pakistan. Journal of Environmental Science and Water Resources, (4): 85 – 94.

[39] Chandrakant, M. and R. Kedar. 2013. Physico-Chemical Analysis and Microbial Degradation of Spent Wash from Sugar Industries. Research Journal of Chemical Sciences, 3(8): 53-56.

[40] Jha, C.K., S.K. Sinha and M. Alam. 2013. Utilization of bio-methanated distillery spent wash and bio-compost for sugarcane production and improving soil fertility. Environment and Ecology, 31 (4) : 1709-1713

[41] Latha, P., G. Thangavel, Rajannan and K. Arulmozhiselvan. 2014. Effect of Distillery Spent Wash on Carbon and Nitrogen Mineralization in Red Soil P. Nature Environment and Pollution Technology: An International Quarterly Scientific Journal, 12 (1) : 163-166.

[42] Khandegar, V. and A.K. Saroh. 2014. Treatment of distillery Spent wash by Electro coagulation. J. of Clean Ene Tech, 2 (3): 244-247.

[43] Anoop, Y. and D. Renu. 2014. Effect of sugar mill on physico-chemical characteristics of groundwater of surrounding area. Int. Res. J. Envir. Sci., 3(6): 62-66.