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RESEARCH ARTICLE

Amendment of Concentration of Sugar Mill Effluent on Soil Properties

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ABSTRACT
Soil pollution caused by countless industrial effluents has become a thoughtful problem. The sugar industries are discharging large quantities of common salts during the processing of cane juice for making sugar. These salts get deposited into the soil when the effluent comes in contact with the soil. The dissolved constituents of the effluent react with soil clay complex leading to accumulation of salts resulting in increase in the amount of exchangeable sodium and other nutrients.
***Key words:** effluents, pollution, soil, salts*

INTRODUCTION
A study on the physico-chemical properties of soil is very significant and is of practical utility in agriculture. It aims at providing a tool for proper management of soil (Altieri and Nichollas, 2003).

STUDY AREA
The present study is about the effect of sugar mill waste of Cooperative Sugar Mills, Meham, Haryana, India on soil of nearby areas. This sugar mill is located at 28°59'49.2"N 76°14'30.1"E. B1 & B2 soil samples were taken from field sprayed with bore well water from last few years and E1 & E2 soil samples were taken from a field which is sprayed with sugar mill effluents for last few years as shown in Figure 1.

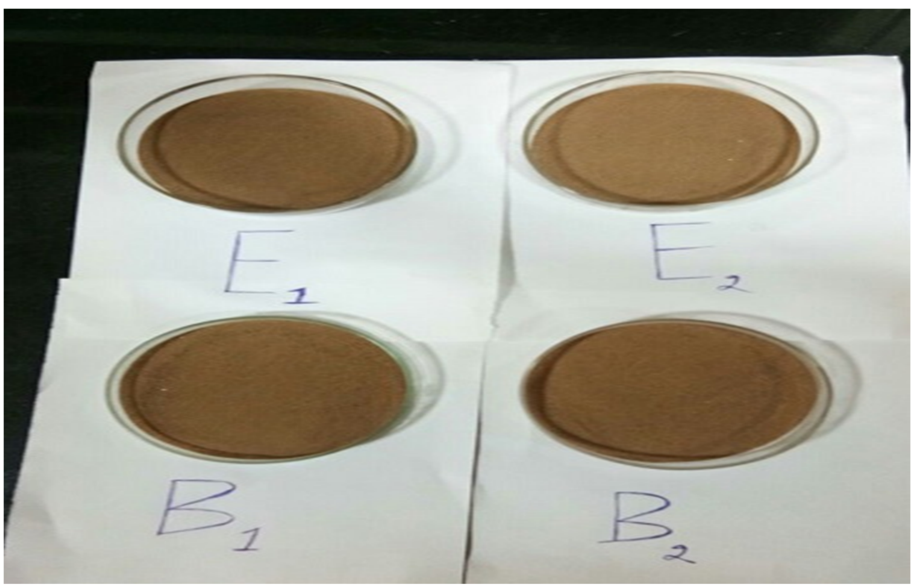

Fig. 1: Soils sprayed with borewell water (B1 & B2) and sugar mill effluents ((E1 & E2)

RESULTS AND DISCUSSION

The sugar mill effluent is acidic in nature as shown in Table 1 and leads to the deterioration of the concrete, metallic pipe through which the effluent passes and thus causes seepage of the wastewater and ultimately into the soil which leads to leaching of nutrients from the soil. Thus, free disposal of the effluent on the land affects the soil properties. Therefore, in the present study, the impact of the sugar mill effluent on the soil properties has been studied and compared with nearby field soil that is not affected by it. Physico-chemical characteristics of both types of soils were analysed *i.e.* Bulk Density, Specific Gravity, pH, EC, Total Organic Carbon (TOC), Moisture Content, Water Holding Capacity (WHC), NO_3^-, PO_4^{-3}, K^+ as shown in Table 1.

BULK DENSITY:

Bulk density is the soil's capacity to function for movement of water and solute, soil aeration and structural support. Bulk density of soil samples B1 & B2 and for E1 & E2 along with their standard deviation are shown in Table 1. Bulk density of soil samples of field sprayed with bore well water is higher than the field which is sprayed with sugar mill effluents. But for both kinds of soils, it is well within the criteria of normal soil level that is below 1.5 g/ml in all the samples.

Table 1: Various Physico-chemical parameters of effluent affected soil

Parameters	B1	B2	E1	E2	BIS
Bulk Density (g/ml)	1.2±0.011	1.2±0.05	1.0±0.020	1.1±0.01	1-1.5
Specific Gravity (g/ml)	2.59±0.02	2.63±0.03	2.03±0.015	2.24±0.03	2.6-2.8
pH	7.59±0.02	7.62±0.02	6.05±0.04	6.25±0.04	7.6-7.8
EC (dS/cm)	1.1±0.015	1.13±0.020	4.06±0.03	4.16±0.04	0.12-1.08
Moisture Content (%)	62.27±3.6	62.9±2.58	52.13±2.60	52.21±1.18	
Water Holding Capacity (%)	47.37±1.95	47.40±2.41	40.99±1.03	40.79±1.51	2.5-14.5
Total Organic Carbon (mg/Kg)	0.49±0.015	0.47±0.03	6.15±0.035	6.22±0.03	2
Nitrate (mg/L)	112±4.95	115±3.12	235±4.12	243±4.56	40
Phosphate (mg/L)	23.75±1.32	24.73±1.21	112.34±3.26	115.34±1.12	20
Potassium (mg/L)	45.34±1.01	46.91±1.04	217.98±1.25	218.14±0.12	80

SPECIFIC GRAVITY:

Specific gravity is the ratio of mass per unit volume. A specific gravity below 1.0 (floats on water) will be more prone to erosion due to wind or rain. It is also an indication of high organic matter not properly incorporated or homogenized. Rich soil with a good balance of clay, silt, sand and organic matter would range between as little as 2.0 up to 2.6 specific gravity.

Specific gravity of soil samples B1 & B2 and E1 & E2 along with their standard deviation are shown in Table 1. Specific gravity of soil samples of field sprayed with bore well water is higher than the field which is sprayed with sugar mill effluents. A soil's specific gravity generally depends on the density of the discrete soil particles and is also supported by Kumar, 2014a. Comparative analysis of specific gravity (g/ml) of soil B1 & B2 and E1 & E2 was done and it was observed that there was decrease in value of specific gravity of the soil of fields which were sprayed by effluent water.

The comparison of values of bulk density and specific gravity of field soil sprayed with BWW and effluent water is shown in Figure 2 and found that it is in the range of normal soil as per BIS norms *i.e.* (1-1.5 g/ml) and (2.6-2.8 g/ml).

The increase in bulk density indicated lower organic matter and more compactness in soils. Higher values of bulk density might be due to their coarse texture and low organic matter content (Swarnam, *et al.,* 2004).

SOIL pH:

pH of soil samples B1 & B2 and for E1 & E2 along with their standard deviation are shown in Table 1. pH of soil samples of field sprayed with bore well water is better than the field which is sprayed with sugar mill effluents.

The measurement of pH shows the acidity and alkalinity of the soil. The pH of soils sprayed with effluent water were lower as compared to the pH of soil receiving tubewell or canal irrigation, indicating a definite influence of sewage water application on soil pH. The pH at a given time shows the status of bio-geochemical processes because the sequential changes in pH are likely due to change in primary production, respiration, mineralization and putrefaction of organic matter in the soil (Singh and Kansal, 1985; Behera, 2006 and Kumar, 2014a).

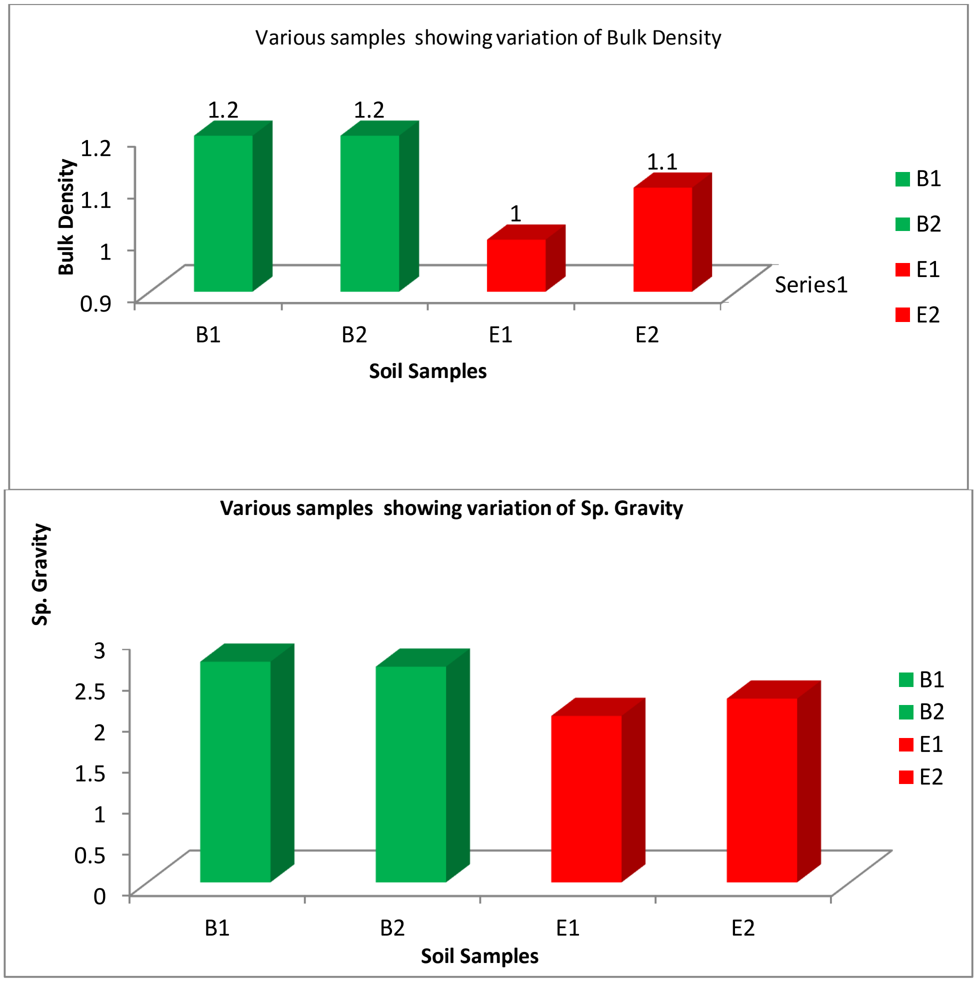

Fig. 2: Comparative analysis of Bulk Density & Specific Gravity (g/ml) of soil B1& B2 and E1&E2

From the evidence available, neither a high value of pH above 8.4 nor a low value below 5.0 is advantageous for maximum yield of crops. The present findings indicate that irrigation with sugar mill effluents considerably decrease the pH value at all the sampling sites. The extent of decrease of pH depends upon the composition of sugar mill effluents and duration of irrigation.

ELECTRICAL CONDUCTIVITY (EC):

The measurement of electrical conductivity gives us clear idea of soluble salts present in the soil as it depends upon number of ions present in soil. EC of soil samples B1 & B2 and E1 & E2 are along with their standard deviation are shown in Table 1.

The comparison of values of pH and EC of field soil sprayed with BWW and effluent water is shown in Figure 3 and found that it is not in the range of normal soil as per BIS norms (0.12-1.08 dS/cm). The increase in EC of effluent water sprayed soil might be due to accumulation of soluble salts in soil receiving irrigation with water of higher electrolyte concentration and the source of these salts in the processing activitities (Hundal and Sandhu, 1990 and Kumar, 2014a).

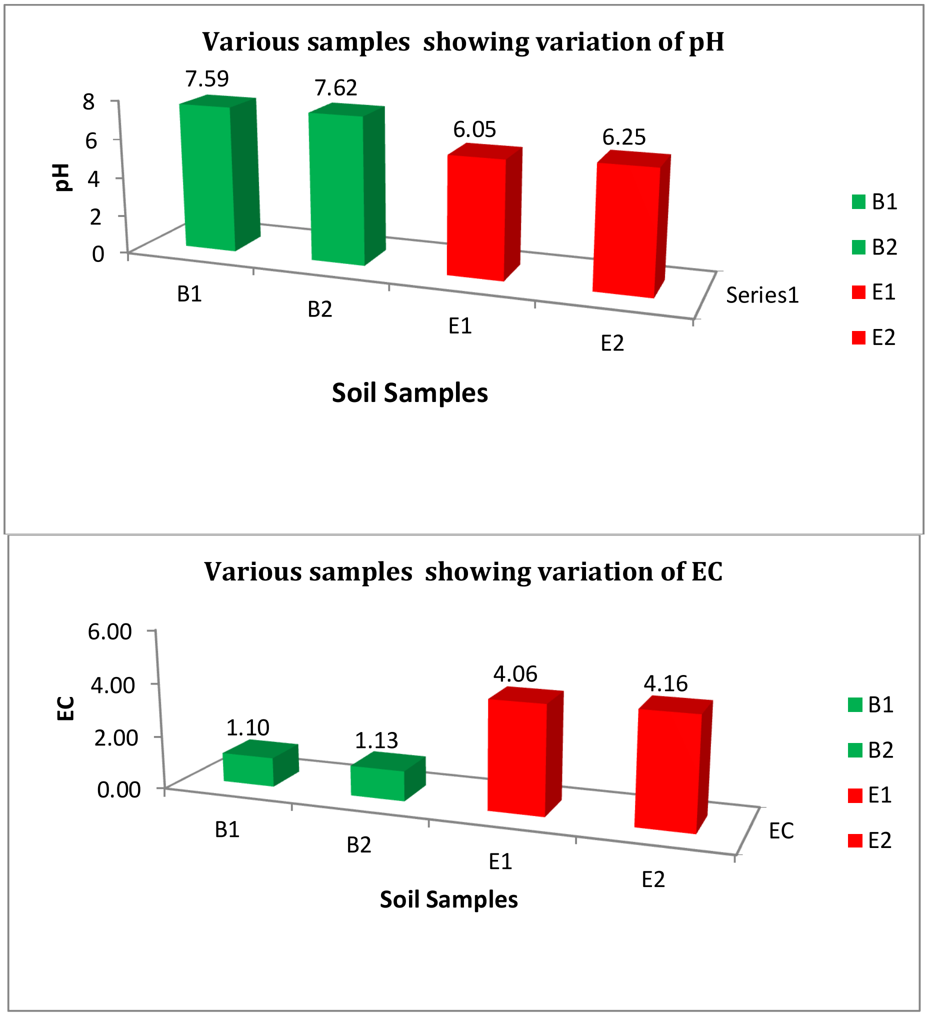

Fig. 3: Comparative analysis of pH & EC of soil samples B1 & B2 and E1 & E2

The decrease in pH of soil may be due to presence of organic acid in the sugar mill effluents. Antil and Narwal, (2005) did not observe any significant change in soil pH because of high buffering capacity of soil and also elaborated that use of sugar mill effluents may develop salinity problem and will render the soil unproductive due to high amount of salt accumulation. A similar kind of variable effect in pH and EC values was also reported by Maiti, *et al.*, 1992; Rao and Santaram, 1994; Gladis, *et al.,* 1996; Mitra and Gupta, 1999; Baddesha, *et al.*, 2002; Ranukaprasanna, *et al.,* 2002; Singh and Chandel, 2006 and Kumar, 2014a).

MOISTURE CONTENT (%):
Moisture content acts as a solvent, maintains the texture and compactness of the soil. It is also used as a habitat by various micro-organisms. Moisture in soil depends upon water holding capacity (WHC) of the soil.

Moisture content of soil samples B1 & B2 and E1 & E2 along with their standard deviation are shown in Table 1.

WATER HOLDING CAPACITY (WHC):
Water Holding Capacity is the amount of water held in the soil after the additional gravitational water has drained away. Good water holding capacity shows good physical condition of soil. WHC of soil samples B1 & B2 and E1 & E2 along with their standard deviation are shown in Table 1. The comparison of values of soil moisture and WHC of field soil sprayed with BWW and

effluent water is shown in Figure 4. Similar results were also reported by (Singaram, 1995 and Kumar, 2014a) in soils of Sivagiri microwatershed in Chittoor district and in soils of Telangana region of Andhra Pradesh.

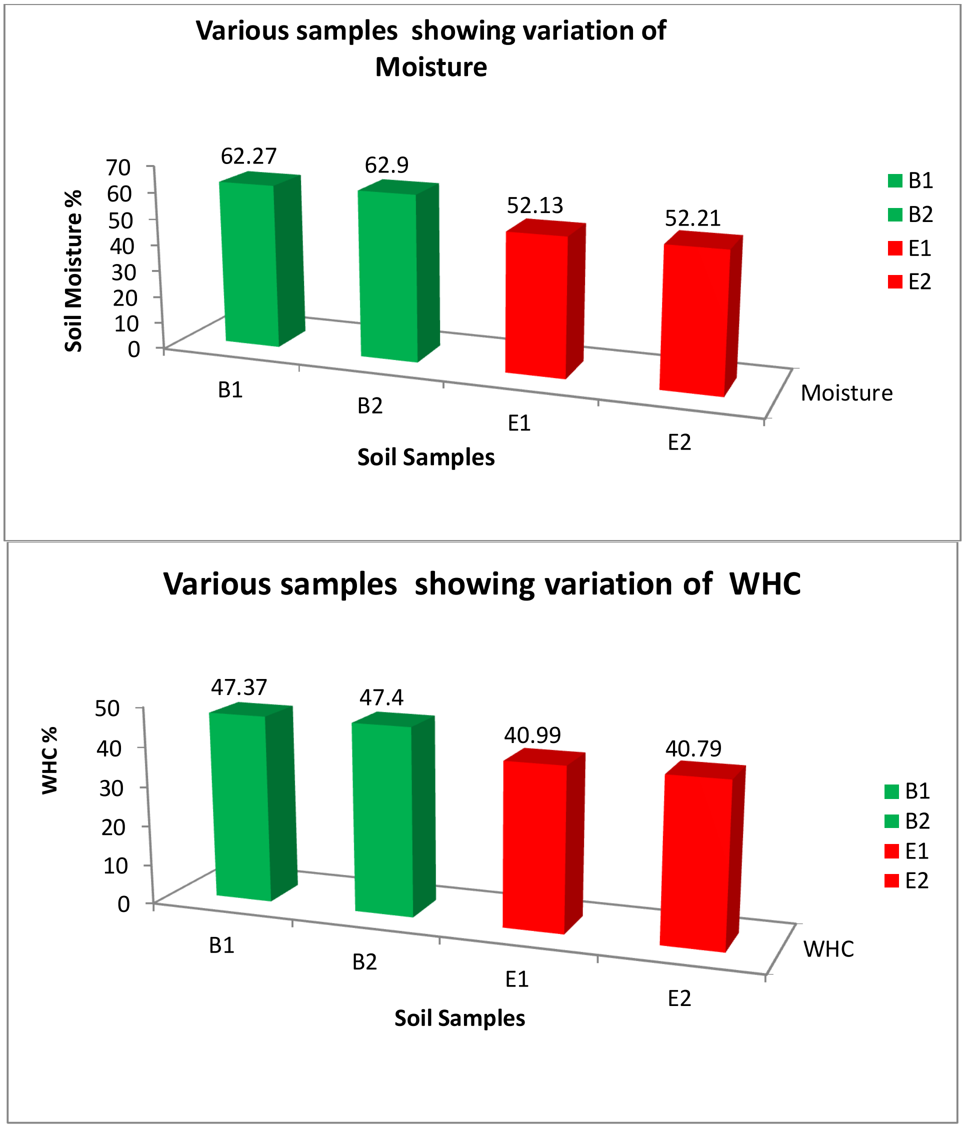

Fig. 4: Comparative analysis soil moisture (%) and WHC of soil samples B1 & B2 and E1 & E2

TOTAL ORGANIC CARBON (TOC):

Total Organic Carbon of soil samples B1 & B2 and E1 & E2 along with their standard deviation are shown in Table 1. Total Organic Carbon of soil samples of field sprayed with bore well water is much lesser (almost 12 fold) than the soil samples of field which is sprayed with sugar mill effluents as shown in Figure 5.

The source of total organic carbon in the given soil include crop residue, animal manure, cover crops, green manure, organic fertilizer *etc*. Increase in organic carbon content in effluent water sprayed soil might be due to addition of organic compounds present in the effluent water (Dutta, *et al.,* 2000). Reddy and Rao, 2000; Malarvizhi and Rajamannar, 2001, Rattan, *et al.,* 2005; Malla and Totawat, 2006 and Kumar, 2014a *etc.* also confirmed that soil receiving effluent water for long term had higher organic carbon than that of tube well/canal water irrigation.

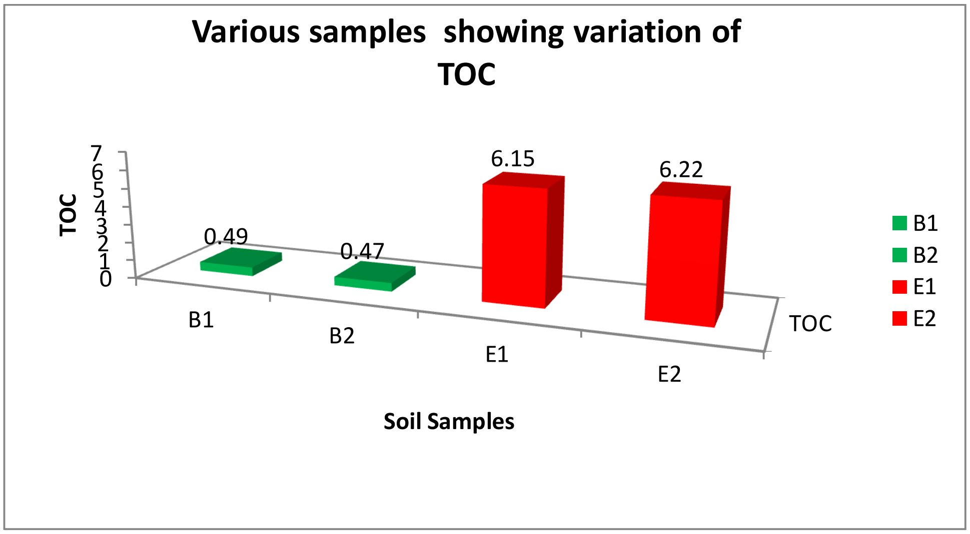

Fig. 5: Comparative analysis of TOC (mg/kg) of soil B1 & B2 and E1 & E2

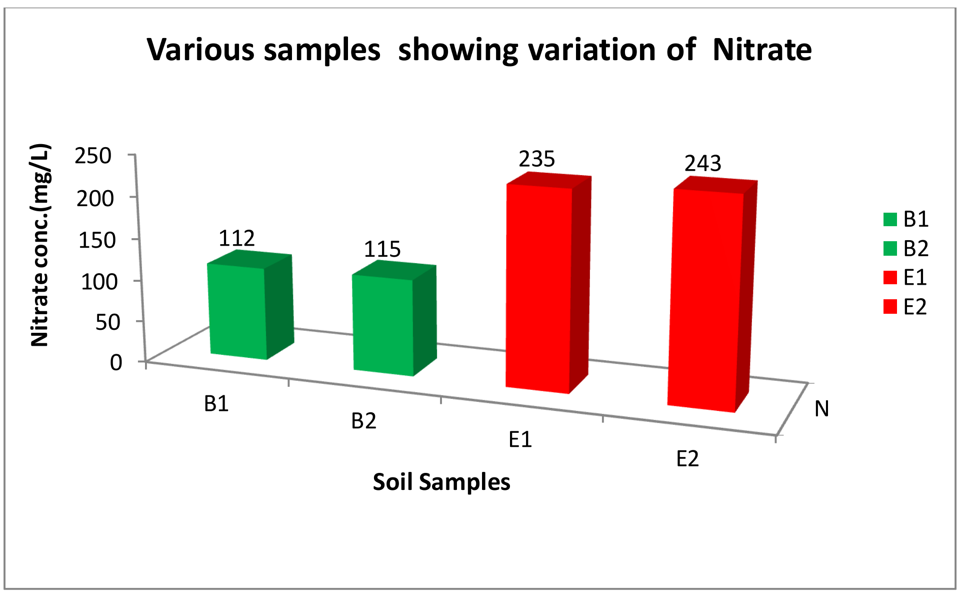

Fig. 6: Comparative analysis of Nitrate (mg/L) of soil B1 & B2 and E1 & E2

MACRONUTRIENT CONTENTS OF SOIL (N, P, K) AS NITRATE PHOSPHATE AND SULPHATE

Nitrogen, phosphorus and Potassium (N, P, K) are the most important macro-nutrients which regulate the plant growth and yield of crops as well. Nitrogen is responsible for giving green colour to the leaves and helps in photosynthesis. It is the compulsory part of all proteins, enzymes and participates in all metabolic processes. It is helpful in growth of plants, increases seed and fruit production, also improves quality of crops. Plant roots take up nitrogen in the form of NH_4^+ and NO_3^-. But higher dose is also dangerous as affecting plant growth negatively.

Phosphorus is also a part of every living cell in plants. Various activities of plants like growth, respiration, reproduction *etc*. depend upon phosphorus. Potassium is vital for photosynthesis, protein synthesis, starch formation *etc.* The analysis of these nutrients in soil is as below:-

NITRATE:

Nitrate of soil samples B1 & B2 and E1 & E2 along with their standard deviation are shown in Table 1. Nitrate of soil samples of field sprayed with bore well water is much lesser (almost half) than the soil samples of field which is sprayed with sugar mill effluents as shown in Figure 6. Its concentration in soil is affected by duration of irrigation, composition of effluent and variation of soil.

The higher available N in effluent sprayed soil is associated with build up of organic matter due to uninterrupted application of sewage water (Azad, *et al.*, 1987). Similar results were also observed by Mitra and Gupta, 1999; Rathore, *et al.,* 2000; Reddy and Rao, 2000; Tiwari, *et al.*, 2003; Kumar, 2014a.

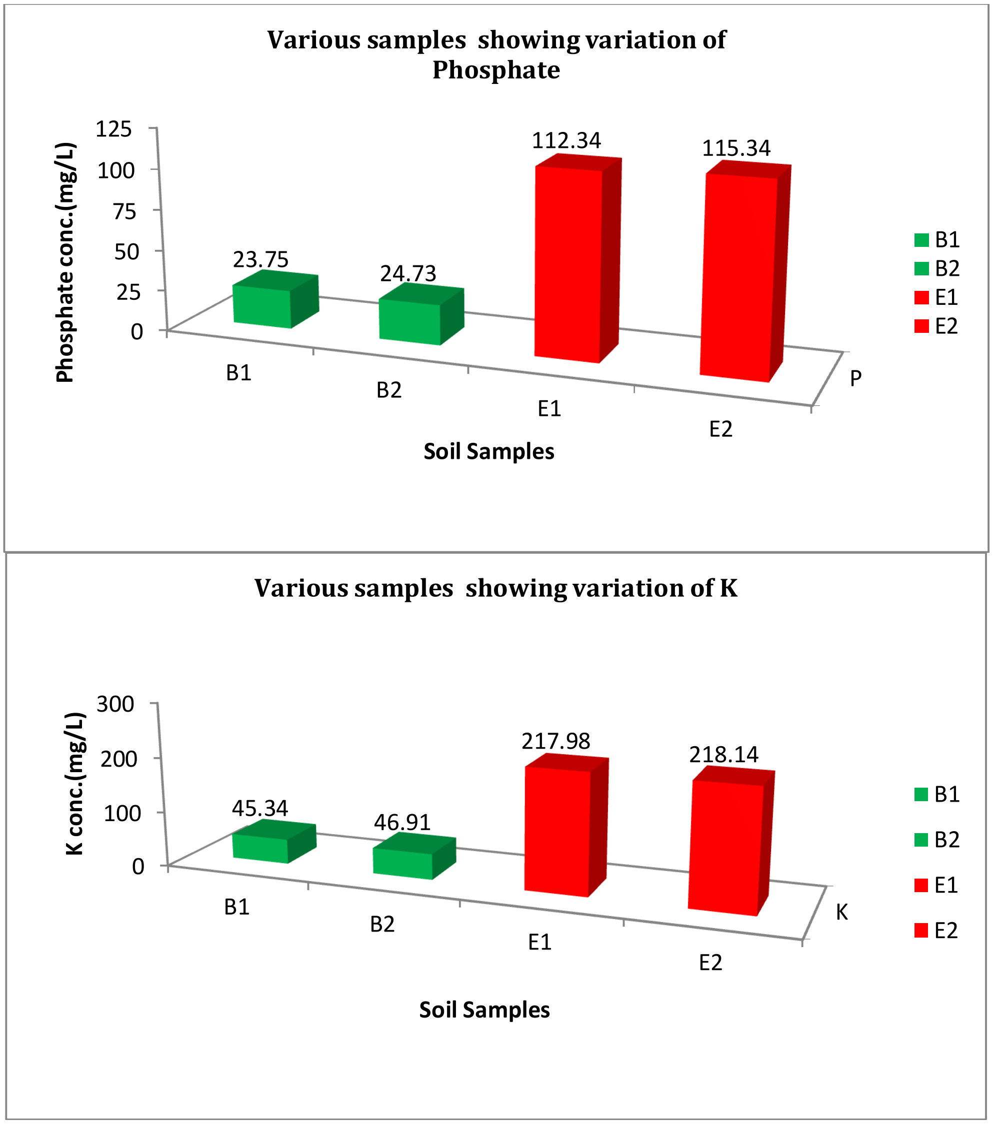

Fig. 7: Comparative analysis of Phosphate & Potasium (mg/L) of soil samples B1 & B2 and E1 & E2

PHOSPHATE & POTASSIUM:

Phosphate and potassium of soil samples B1 & B2 and E1 & E2 along with their standard deviation are shown in Table 1. Phosphate and potassium of soil samples of field sprayed with bore well water is much lesser (almost one sixth and one half respectively) than the soil samples of field which is sprayed with sugar mill effluents as shown in Figure 6. The greater content of available P in sewage water sprayed soil might be due to the fact that considerable amount of P is present in effluents (Somasekhar, *et al.,* 1984; Azad, *et al.*, 1987; Baruah, *et al,.* 1993; Sundaramoorthy, 1995; Reddy and Rao, 2000; and Kumar, 2014a).

The nitrogen, phosphorus and potassium contents of plant tissue had definite correlations with the effluent concentrations. The maximum contents of them were generally observed in plants sprayed with the treated effluent 25 % to 50 % and 100 % effluent concentrations.
Under normal conditions, it is logical to expect higher accumulation of N, P and K in plants treated with effluents of higher concentrations due to the liberal availability of NO_3^-, K^+ and PO_4^{3-}. Lokhande, (2013) had recorded increased nitrogen contents in *Dichanthium* growing in soil polluted with distillery effluent.

CONCLUSION

Significant changes in the chemical characteristics of the soil as a consequence of treatment with effluent have been recorded in the present study. All the studied parameters viz., Bulk Density, Specific Gravity, pH, EC, Total Organic Carbon (TOC), Moisture Content, Water Holding Capacity (WHC), NO_3^-, PO_4^{-3}, K^+ of the treated soils registered increase over their controls receiving bore well water only and the increases were linearly related to the concentrations of the effluent added.
Similar observations showing increase in the pH and electrical conductivity and build-up in the contents of organic carbon, soluble salts and available nutrients in the soil due to continuous irrigation with effluent has been made by a number of earlier investigators (Rajanan and Oblisami, 1979; Somashekar, *et al.,* 1984; Juwarkar, *et al.*, 1987; Kannan and Oblisami, 1990, 1990a; Kalaichelvi, 2010).

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