International Multidisciplinary Research Journal 2013, 3(1):18-22
ISSN: 2231-6302
Available Online: http://irjs.info/

INTERNATIONAL MULTIDISCIPLINARY RESEARCH JOURNAL

Effect of Sugar Factory Effluent on Physico-Chemical Properties and Cellulase Activity of Soil - A Case Study

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Abstract

The objective of the present study was to investigate alterations in soil properties under the influence of sugar factory effluent. An assessment was done on the effect of sugar factory effluent on physicochemical properties and cellulase activity of soil near sugar factory at Chahardi, Maharashtra, India. Soil samples were collected from 7 sampling sites near the sugar factory during 2011-2012. The experimental results indicated that most of the physicochemical properties of soil including pH, electrical conductivity and some nutrients, viz. N, P, K, Zn, Pb, Cu, and Fe as well as soil cellulase activities shown statistically significant fluctuations ($p<0.05$). The pH and EC shown inverse relationship as the distance between sources of effluent and sampling site increased. Progressive increase in soil cellulase activity was noted as the sampling sites increased distance from the effluent storage site. There is a need for periodical assessment of soil quality in the vicinity of sugar factory and this information should be provided to farmers for maintenance of soil fertility.

Keywords *:* Sugar factory, effluent, physico-chemical properties and soil cellulase activity

INTRODUCTION

Industrial revolution played significant role in development of the nation. Consequently, the industrial activity has expanded so much all over the India. Today, it has become a matter of major concern in the deterioration of the environment. With the rapid growth of industries including sugar, paper, tannery, textile, sago, and dye in our country, pollution of natural water by industrial waste water has increased tremendously. Among the effluent discharging industries, sugar mills plays a major role in polluting the water bodies [1]. Diverse sugar industry effluents disposed of in soil and water cause major pollution problems. The sugar industry plays an important role in the economic development of the region, but at the same time untreated effluents produce a high degree of organic pollution in both aquatic and terrestrial ecosystems [2]. These in- turns ultimately affect the agriculture production and food security. Polluted soil and water also acts as secondary source of pollution.

India is an agricultural country and Maharashtra is one of the major producers of sugar. During 2010-11, 167 out of 209 sugar factories in Maharashtra State have crushed 80.215 million tons of sugarcane producing 9.052 million tons of sugar at a recovery rate of 11.31% [3]. In North Maharashtra region, there are many sugar factories that operate about 4 to 8 months in a year and during this period they produce large amount of waste matter. This waste matter (effluents) is released into nearby water bodies or on land. These effluents (spent wash) contain many harmful chemicals. In Maharashtra, about 160 sugar factories producing sugar and also releasing harmful waste matter in the surrounding [4]. This large amount of chemicals could disturb the quality of ground water as well as soil contaminated with spent wash.

The effluents of sugar factory percolate in the soil and reach the ground water table. These effluents affect the ground water quality by changing its chemical composition [5]. Similarly, an effect of sugar factory effluent on some physico-chemical properties of soil was done by Roy et al [6]. Another report indicated the effect of irrigation by sugar factory effluent (spent wash) and the well water from adjoining area of sugar factory in Wardha district of Maharashtra [7]. Ajmal and Khan [8] evaluated the physico-chemical properties of effluents of Kisan Sahkari Chini Mills Limited Satha, Aligarh (UP) India and Panniji Sugar and General Mills, Bulandshahr (UP) India. Pertaining to available literature and considering the need of hour, the present work was undertaken to assess effect of sugar factory effluent on physico-chemical properties and cellulase activity in adjoining agricultural soil.

Study Area The area around the Chopda Sugar Factory locate in the vicinity of village Chahardi Tal: Chopda, District: Jalgaon Maharashtra state, at longitude 21°15'N 75°11'E and latitude 21.25°N 75.18°E (Figure 1). The mean sea level is of 190 meters. The site is surrounded by the sugar cane growing agricultural land in addition to cotton, banana, wheat and other grains. At the rate of about 1600 metric tons of sugar cane is crushed per day while in each year about 1,40,000 metric tons of sugarcane is processed for manufacturing sugar in Chopda sugar factory. Factory is also contributing in electricity generation at an average rate of 7000 units

Received:; Revised; Accepted.

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in each operative period. The information of study area is retrieved from The Gazetteers Department of Maharashtra.

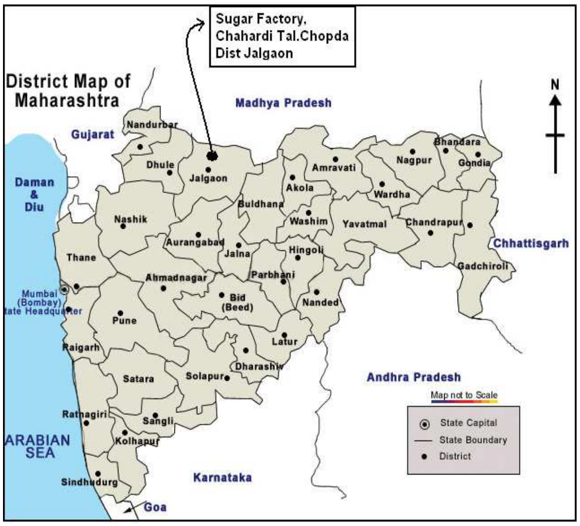

Fig. 1. .Location of Sugar factory in Chopda tahsil of Jalgaon district in Maharashtra. [Source: The Gazetteers Department of Maharashtra]

Materials and Method

The agricultural soil samples (from top 20 cm layer of an agricultural land) were collected from 7 sampling sites located at 0 (SS_1), 0.25 (SS_2), 0.5 (SS_3), 0.75 (SS_4), 1.0 (SS_5), 1.5 (SS_6) and 2.0 km (SS_7) away from the sugar factory during 2011-2012. The air dried soil was crushed, sieved and processed for assessment of following parameters:

a) Soil pH was measured in 1:5 solution of soil and water extract after shaking for 30 min. [9].

b) An electrical conductivity, available nitrogen, potassium, Iron, lead, zinc, copper and phosphorous were determined by chemical analytical methods as described by Delavalle [10].

c) The estimation of soil cellulase activity was done by method described by Miller [11] and Leoppert et al [12]. Paper is the source of cellulose, the reducing sugars released as a result of cellulase action on cellulose is estimated by the dinitro salicyclic acid (DNSA) method using D-glucose as the sugar standard. Finely cut-pieces of Whatman No. 1 paper, 0.01 g was incubated with the enzyme sample dissolved in 0.2 M Na-acetate buffer, pH 4.5 at 30^{0}C for 1 h. One mL of this sample (without the paper) + 1 mL of DNSA reagent were incubated in a boiling water bath for 10 min. It was then cooled to RT, the total volume was brought to 10 mL with DW and the absorbance was spectrophotometrically recorded at 546 nm. The blank was enzyme free.

Results and Discussion

Physico-chemical parameters of soil samples collected from SS_1 to SS_7:

pH: The pH value is measured for all locations (SS_1 to SS_7) and its values ranges from 5.7 ± 0.3 to 6.8± 0.4. The location SS_1 records the minimum values 5.4 and the location SS_7 records the maximum values 7.2. The pH values shown increasing trend i.e. from acidic to neutral range as sampling sites were away from the source indicated that sugar factory effluent was acidic in nature. Nomulwar and Patil [8] recorded pH values 6.6 for a control soil they had chosen where as Bakkialakshmi et al [13] reported pH values ranged from 6.7 to 7.6 in soil samples contaminated with sugar factory effluent. Soil pH is an important consideration for farmers and gardeners for several reasons; including the fact that many plants and soil life forms prefer either alkaline or acidic conditions that some diseases tend to thrive when the soil is alkaline or acidic, and that the pH can affect the availability of nutrients in the soil. Many plant diseases are caused or excerbated by extremes of pH, sometimes because this makes essential nutrients unavailable to crops or because, the soil itself is unhealthy. For example, chlorosis of leaf vegetables and potato scab occur in overlay alkaline conditions, and acidic soils can cause clubroot in brassicas. The variation of pH with the sampling stations is given in Fig. 2.

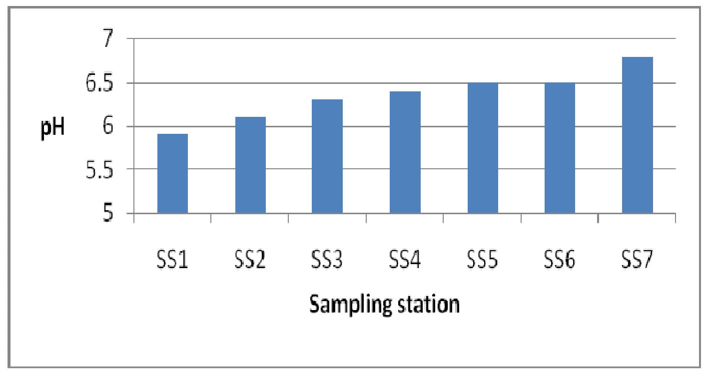

Fig. 2. Variation in pH of soil at SS_1 to SS_7 near Chopda sugar factory during 2011-12

Electrical conductivity (EC) The EC value is measured for all location (SS1 to SS7) and its value ranges from 0.12 ± 0.02 dsm^{-1} to 0.37 ± 0.03dsm$^{-1.}$ The SS_1 records maximum value 0.14 dsm^{-1} and the location SS_7 records minimum value 0.4 dsm^{-1}. EC values shown decreasing trend as the sampling stations were away from the source. In addition to these observations, it was found that there was inverse relation between pH of the soil contaminated with sugar factory effluent and its EC values. Senthil *et al.*, [14] recorded EC value 0.5 dsm^{-1} for a good soil they had chosen. The variation of EC with the sampling station is given in fig. 3.

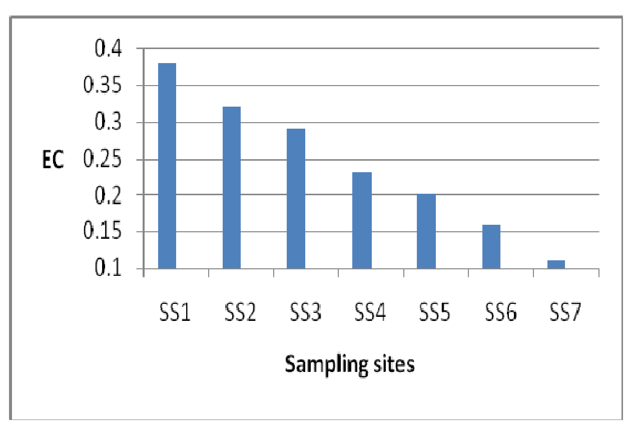

Fig. 3. Variation in EC of soil at SS_1 to SS_7 near Chopda sugar factory during 2011-12.

Nitrogen and Potassium Contents The nitrogen content in the soil samples shown fluctuation within the range of 88±4 Kg/ha to 97±5 Kg/ha (figure 4) where as potassium content in soil samples shown variations between 139 ±11 Kg/ha to 152±14 Kg/ha (figure 5). There was increasing trend in nitrogen and potassium contents from SS_1 to SS_4, and then at SS_5, the value of nitrogen content reported its lowest values which later went on increasing from SS_5 to SS_7. Similarly, potassium content in soil sample collected at SS_6 had slightly higher values than that of SS_7. The variations reported in the nitrogen and phosphate contents in the soil samples collected during the study period may not have any direct relationship with the sugar factory effluent. The results resemble with that of Nomulwar and Patil [7] and Ajmal and Khan [8].

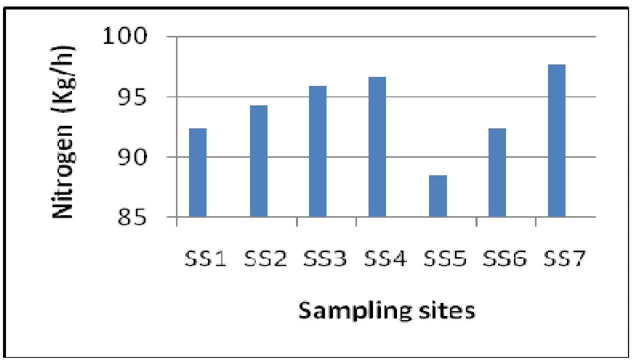

Fig. 4. Variation in Nitrogen content of soil at SS_1 to SS_7 near Chopda sugar factory during during 2011-12.

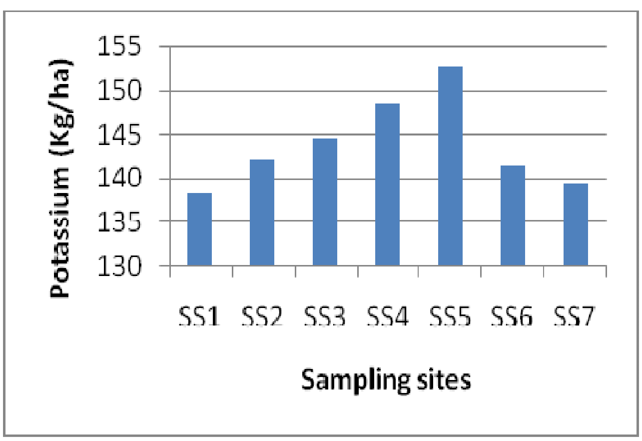

Fig. 5. Variation in Potassium content of soil at SS_1 to SS_7 near Chopda sugar factory at SS_1 to SS_7 near Chopda sugar factory during during 2011-12. 2011-12.

Iron, Lead, Zinc and Copper content

The variations in iron content in soil samples collected from SS_1 to SS_7 are shown in fig.6, which indicated that its value decreased from 21±1.2 at SS_1 to 17±0.8ppm at SS_4. Further at SS_5, its higher value (19.5±0.5) dropped to lower values (16.6±0.3) at SS_7. The lead content in soil samples shown downtrend from SS_1 to SS_7 (fig.7). The maximum and minimum values of lead content were 0.4±0.03ppm and 0.2±0.04ppm respectively. Similar to lead content, decreasing trend was reported in zinc content of soil samples collected from SS_1 to SS7 (fig.8). The zinc content had highest value of 5.9±0.05ppm and lowest value of 2.4±0.02ppm. The copper content in the soil samples decreased from its higher value (0.71±0.04ppm) to lower values (0.43±0.05ppm) from SS_1 to SS_6 (fig.9). However, at SS_7 the value of copper content was found increased. Bakkialakshmi et al [13] reported somewhat similar trend in iron, lead, zinc and copper content in soil affected due to Thiru Aruran Sugar factory in Tamilnadu.

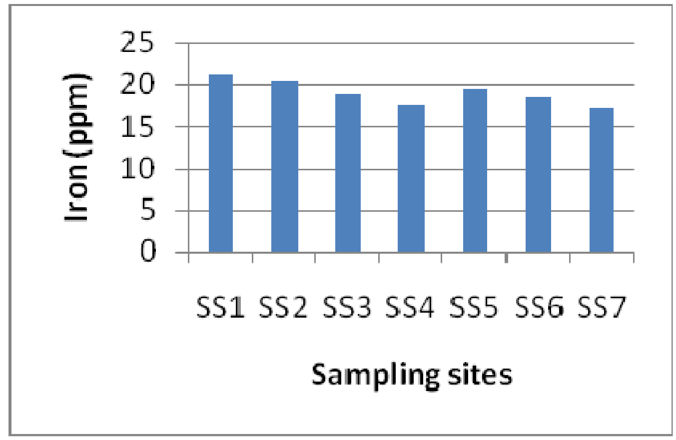

Fig. 6. Variation in Iron content of soil at SS_1 to SS_7 near Chopda sugar factory during 2011-12.

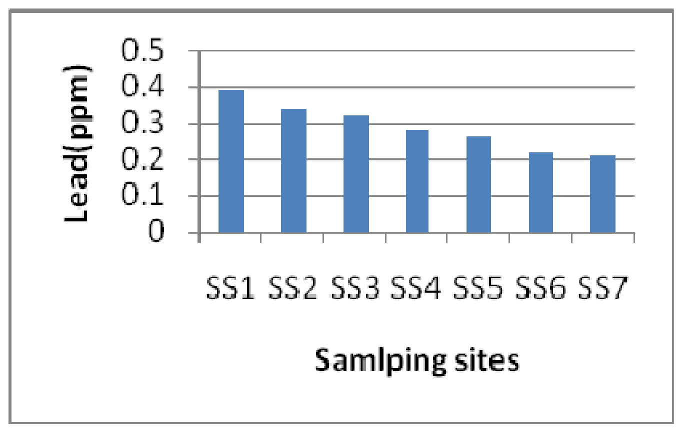

Fig. 7.Variation in Lead content in soil at SS_1 to SS_7 near Chopda Sugar factory during 2011-12.

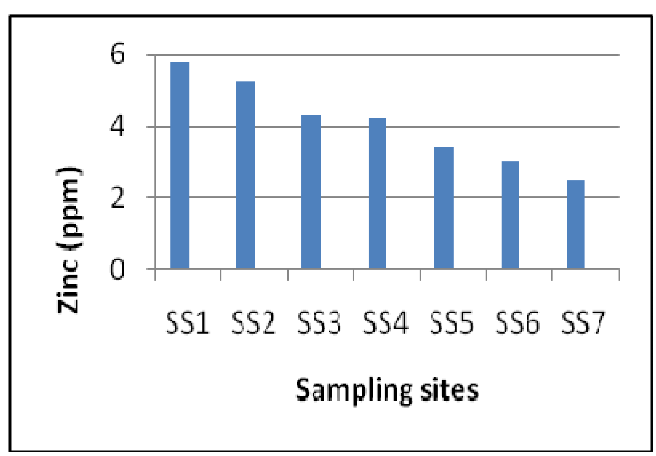

Fig. 7.Variation in zinc content in soil at SS_1 to SS_7 near Chopda Sugar factory during 2011-12.

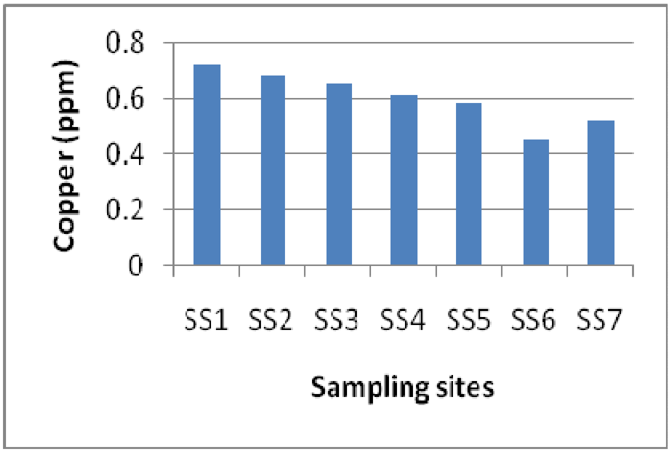

Fig. 8. Variation in Copper content of soil at SS1 to SS7 near Chopda sugar factory during 2011-12.

Phosphate Content

The variation in phosphate content in soil samples is shown in fig 10, which indicated that except at the SS_6, there was increasing trend from its lower value (42± 8.2 Kg/ha) at SS_1 to its higher value (52± 5.3 Kg/ha) at SS_7. Senthil Kumar et al [14] noted 94± 6.6 Kg/ha phosphate value in soil contaminated with sugar factory effluent.

Soil cellulase activity

Soil cellulase activity in soil samples collected from SS_1 to SS_7 within 2 km periphery of Chopda sugar factory during the study period was estimated on the basis of conversion of cellulose into glucose by cellulase enzyme released by soil microbes. (Table 1). The soil cellulase activity is measured in µmol of substrate consumed /g soil DW/h. It was evident that soil cellulase activity shown statistical increasing trend from SS_1 to SS_7 [15]. Similar trend in soil cellulase activity in sugar factory effluent contaminated soil were reported by earlier investigators [7, 8, 13 and 14].

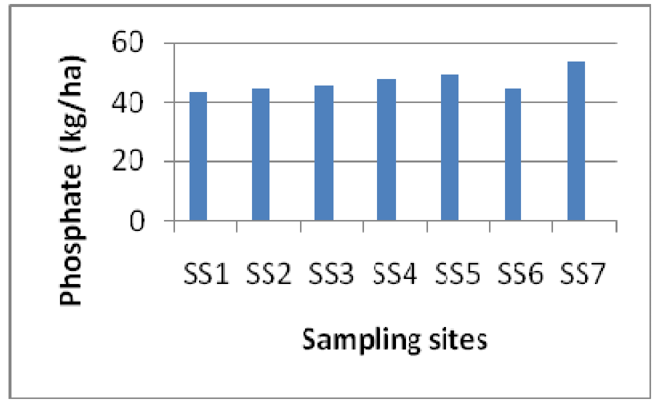

Fig. 10. Variation in Phosphate content at SS_1 to SS_7 near Chopda sugar factory during 2011-12.

Table 1. Soil cellulase activity (µmol of substrate consumed /g DW/h) in soil samples collected from sampling sites SS_1 to SS_7 at Chopda sugar factory during 2011-12.

Parameter	SS_1	SS_2	SS_3	SS_4	SS_5	SS_6	SS_7
Soil cellulase activity	0.95±0.03	1.27 ±0.06	1.68±0.04	2.34±0.05	2.73±0.05	3.12±0.04	3.23±0.05

Each figure is Mean ±SD of six observations.

Conclusion

The Chopda sugar factory effluent was found stored in big sized pits without any concrete construction near the factory itself from where it percolated in the adjoined farmland and might cause the changes in physicochemical properties of the soil samples collected from SS_1 to SS_7. The soil samples collected from sampling sites shown transforming trend from acidic to neutral as distance of sampling site went on increasing from the sugar factory [16]. There was inverse relation found in EC and distance of the sugar factory i.e. less was the distance of sampling site from factory, more of the EC values of the soil indicated that effluent percolated from pits increased the electrical conduction of soil [17]. The fluctuations in Nitrogen, Potassium, Phosphorus, Iron, Lead, Zinc and Copper shown statistically significant fluctuations ($p<0.05$) which might be an impact of sugar factory effluent percolated from storage site [1,7].

There was increase in soil cellulase activity as the sampling sites increased it distance from the effluent storage site. The progressive increased soil cellulase activity may be related to increase of cellulase producers as a result of changes in soil microbial communities and adsorptions and immobilization of enzymes on soil colloids and organic matter [18 and 19]. Burns [20] suggested that a fraction of soil enzymes is associated with living microorganisms, other fractions are associated with non-living, and particulate matter of the soil matrix and the rest is present in the soil water solution (free enzymes). Enzymes are able to be absorbed and immobilized by clay minerals and humic colloids in soil environments [19]. The exogenous and immobilized enzymes are less susceptible to denaturation and can have an important ecological effect on soil quality, because biochemical activity could remain in soil despite rapid reduction of microbial population, thereby playing a very important role in the decomposition of organic matter in soil and germination of seed [21].

Acknowledgement

Authors are grateful to Adv. Sandeep S. Patil, The President of Mahatma Gandhi Sikshan Mandal Chopda, Jalgaon and President of Chopda city and Dr. Smita S. Patil, Secretary of MGS Mandal for their continuous encouragement and to the Principal, MGSM's ASC College, Chopda (Dist. Jalgaon) for providing necessary laboratory facilities.

References

[1] Amathussalam, A., Abusbacker, M.N and Jayabal, N.J. 2002. Physico-chemical parameters and concentration of heavy metals in sugar industry. *Ind. Poll.Con.* 13: 118- 119.

[2] Ayyasamy P.M, Yasodha R, Rajakumar S, Lakshmanaperumalsamy P, Rahman Lee S. 2008. Impact of sugar factory effluent on the growth and biochemical characteristics of terrestrial and aquatic plants. Bull. Environ. Contam. Toxicol., 81: 449- 454.

[3] Department of Agriculture, Maharashtra. 1969. “Board soil zones of Maharashtra”

[4] National Federation of Cooperative Sugar Factories Ltd (NFCSFL) 2002: Financial Daily from THE HINDU group of publications Monday, Sep 30, 2002.

[5] Pondhe G. M, Pawar N. J, Patil S. F. 1992. Impact of sugar mill effluents on groundwater, Poll, Res. 16 (3).

[6] Roy R. P, Prasad J, Joshi A.P. 2007, Journal of Environment Science Eng. Octo. 2007; 49 (4) 277-282.

[7] Nomulwar Poonam and P. M. Patil 2005. Impact of distillery industry on the quality of ground water and soil. J. Aqua. Bio. Vol. 20 (1) 49-51.

[8] Ajmal Mohammad and A. U. Khan.1983. Effects of sugar factory effluent on soil and crop plants. *Envt Poll. Series A, Ecological and Biological*, Vol 30(2), p 135-141.

[9] Hesse P. R. 1971. A textbook of soil chemical analysis. John Murray, London.

[10] Delavalle, N. B. 1992. Handbook on reference methods for soil analysis. Quality assurance plans for agricultural testing laboratories: p. 18 - 32. *Soil and Plant Analysis Council*, Inc. Athens.

[11] Miller G.L. 1959. Use of dinitro-salicylic acid reagent for determination of reducing sugar. *Analytical Chemistry, 31*: 426–428.

[12] Leoppert R. H; Saurez G. L. 1996. Sparks D. L. (ed). *Methods of soil analysis*. Part 3. Chemical methods.

[13] Bakkialakshmi S., B.Shanthia, S.Barkavi, V.P.Chitra and A.Jarlet jeyaseeli. 2011. Spectro-chemical study of Thiru Aruran Sugar factory waste affected soil in A Sithoor, Cuddalore District, Tamilnadu, India. *Scholars Research Library Archives of Physics Research*, Vol. 2 (2): 142-148.

[14] Senthil Kumar R.D., R.Narayana Swamy, K.Ramkrishan.2001. Pollution studies on sugar mill effluents physicochemical characteristic and toxic metals. *Poll. Res. 20(1):91-97.*

[15] Gurumani, N. 2005. An Introduction to Biostatistics 2nd edn. MJP Publishers, Chennai.

[16] Ferris H, Lau S. 1995. Respiration and metabolic rates based on carbon dioxide production. *Soil Biol. Biochem.* 27. 319- 330.

[17] Kristian K. Brandt., Rasmus. J.N. Frandsen, Peter E. Holm and Ole Nybroe, 2010. *soil biology & Biochemistry,* 42: 748-757.

[18] Kang H, Freeman C, Lee D, Mitsch W. J. 1998. Enzyme activities in constructed wetlands; implications for water quality amelioration. *Hydrobiologia*, 368; 231-235.

[19] Safari Sinegani A.A., Emtiazi G., Shariatmadari H. 2005. Sorption and immobilization of cellulose on clay minerals. *Journal of Colloid and Interface Science*, *290*: 39–44.

[20] Burns R.G. 1982. Enzyme activity in soil: location and a possible role in microbial ecology. *Soil Biology and Biochemistry, 14*:423–427.

[21] Sajani Samuel and S.M Muthukkaruppan 2011. Physico-Chemical Analysis of Sugar Mill Effluent, Contaminated Soil and its Effect on Seed Germination of Paddy (*Oryza sativa* L.) *Intern'l J of Pharma & Biol Arch.* 2(5):1469-1472..