JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Effect of Sugar Mill effluent on Physico-chemical Properties of Soil in Yamuna Nagar Haryana

[1]Vijay Sharma and [2]Deepak Kumar

1. Associate Professor Department of Industrial Chemistry Guru Nanak Khalsa College Yamuna Nagar Haryana India
2. Department of Chemistry Government College for Girls 14 Gurugram Haryana India

ABSTRACT

Due to increasing industrialization and urbanization, waste water pollution is increasing day by day. The disposal of waste water from Sugar Industry in Yamunanagar is seriously changing the properties of agricultural soil. Huge amount of water is consumed in the sugar industry, on an average 20-30 tons of water is needed to process 1 ton of sugar. Sugar industry is one of the most polluted industries in India. India is the second largest producer of sugar in the world. Waste water of Sugar Industry is usually all active in nature. It also contains high contents of bicarbonates, carbonates, phosphates, nitrates and heavy metals ions. It also has high value of BOD, COD, Suspended solids, dissolved solids and total solids. It was observed in the study areas that the effluent of sugar mill affects the physico-chemical properties of the soil. Irrigation with sugar mill effluent has lead to increase the soil alkalinity pH, electrical conductance, organic carbon and available nutrients. The concentration of N, P, K and Na also increased in the soil after irrigation with effluent of Sugar Mill as compare to water from the well. Soil samples have been collected from the affected areas as well as from the sites where irrigation is done with well water. All the contaminants found in the soil samples of various sites where irrigation is done with sugar mill effluent were not to be found in permissible limit. Concentration of heavy metals was found higher in surface layer than the subsurface layer of soils. High concentration of heavy metals become phytotoxic and affects plant development and its growth. This study observed that the soils were contaminated badly due to the discharge of sugar mill effluent in these areas.

INTRODUCTION

Due to green revolution, economic growth, urbanization, industrialization always creating stress and threat to various fresh water resources [1]. It is estimated that nearly 70% of our water sources are polluted. Due to increasing industrialization, the disposal of industrial effluents on agricultural lands is becoming a major source of heavy metal contamination in irrigation soil [2-3] and in ground water. The pollution of water bodies

is mainly caused by the merging of untreated effluents from various industries like Paper Mill, Sugar Mill, Distilleries, Fertilizers, Pesticides, Tanneries, Dye Industries, Textiles, Oil Refineries, Metal Industries, and Pharmaceutical etc. [4-5].

Therefore disposed of waste water from these industries on land is a other alternative. Soil is believed to have a capacity for receiving and decomposing wastes and pollutants whereas organic materials are stabilized through the activity of microbial flora in the soil. Maintaining the soil health is essential for long term sustainability to meet the growing demand of food, fibres and fuel for increasing population. Many industries in all over world discharge their solid waste as well as liquid waste directly on land which causes serious threat to mankind. Soil contamination by heavy metals in a very critical factor because metals are difficult to remove from soil and hence they are very toxic for human beings always as microorganism in the soil and animals. They cause various diseases through the food chain [6-7]. The uptake of toxic heavy metals and other chemicals from contaminated soils by various vegetable crops and other crops pose a serious threat to human health and should therefore be minimized. These contaminants cause serious disease like minamata, bronchial asthma, Itai-Itai and Molybdenosis. Excess of copper causes sporadic fever, hypertension and Uraemia. Chromium causes central nervous system disease [8]. Zinc causes vomiting, cramps and renal damage.

The disposal of waste water from sugar industry on soil leads to the deterioration of soil physical, chemical and biological properties. Sugar industries in the country discharge huge volume of colored and toxic waste water on the soil. On an average, 20-30 ton of water is needed to process one ton of sugar. Sugar industries are one of the most polluting industries. A sugar industry with a capacity of 2500 ton crushed per day will generate about 450 ml of waste water [9]. The sugar mill effluent has a BOD of around 1500 mg L-1 and it appears clean initially. After being stagnated for some time, it turns black and starts emitting foul odour in untreated effluent is discharged on land or in water bodies [10]. Farmers, who have been using such effluents for irrigation, have found that the crop growth, yields were reduced and the soil health also get effected [11]. Sugarmill effluent contains harmful substances like Mn, Pb, Fe, Cu, Zn and various soluble salts [12]. Use of untreated sugarmill effluent on land for irrigation damage soil health and cause serious health problems.

Yamunanagar is the second biggest industrial town in Haryana. There are many major industries like Sugar mill, Pulp and Paper Mill, Distillery, Starch Mill, Metal Industries etc. Many of these industries discharged their waste water without any recommendable treatment directly in to water or on agricultural land, which affected the various physic-chemical properties of soil as water bodies or on agricultural land, which affected the various physic-chemical properties of soil as well as water bodies [13]. Saraswati Sugar Mill discharged their waste water on land and in the main gandha nallah. Effluent of Sugar Mill contains a number of pollutants such as Phosphate, Carbonates. Bicarbonates, Nitrites, Total Suspended Solids, Dissolved Solids, Volatile Solids and Heavy Metal ions were reported. The pH of effluent was acidic to neutral with high electrical conductivity. The waste water had high BOD and COD value. The effluent containing rich Organic Carbon contents were

reported. Irrigation with untreated Sugar Mill effluent led to increased pH, Electrical Conductivity, Organic Carbon, Available Nutrients, Nitrogen, Phosphorus, Potassium and Na Contents. Indiscriminate use of this water directly on land for irrigation must damage the soil health in Yamuna Nagar areas in a few years. In view of this, the present study was under taken to characterize the various Physico-chemical parameters of Sugar Mill effluents and its impact on the physico-chemical properties of soil with effluent irrigation as compared to the irrigation with well water.

MATERIALS AND METHODS

Sugar Industry and the experimental fields were located in the industrial area of twin cities of Yamunanagar and Jagadhri Haryana India. The effluent of Sugar Mill and well water from the adjoining area were collected and various physico-chemical studies i.e. pH, Conductivity, Total Hardness, Total Solids, Free CO_2, Permanent Hardness, Suspended Solides, Chloride Contents, DO, BOD, COD, Calcium, Magnesium were undertaken by using the standard methods of water analysis [14]. Soil samples were collected from the same selected location points. The same selected location points. Surface soil samples (0-15 cm) and sub surface soil samples (15-30 cm) were collected from the areas where effluent discharged on land and from well water irrigated land in different seasons. The soil samples were dried in an oven at 40 °C until a constant weight was obtained. Now the sample were ground with the help of pestle mortar and then passed through 2 mm stainless steel sieve. After mixing thoroughly these soil samples were stored in polythene bags and used for various physico-chemical analysis of soil using standard methods of soil analysis [15]. pH and electrical conductivity were determined in (1:2). Soil water suspension with the help of glass electrode pH meter and conductivity meter bridge respectively. Nitrogen was determined by Kjeldahl's method [16]. Organic Carbon was estimated by following the Walkly and Black rapid titration method described by Jackson [17]. Total phosphorous was estimated. Potassium and Sodium were determined in ammonium acetate extract using flame photometer. DTPA extraction method was used to determine heavy metals with the help of Atomic absorption spectrophotometer [18].

RESULT AND DISCUSSION

Physico-chemical Studies of Sugar Mill Effluent and Well Water

The colour of the effluent from sugar mill was blackish grey with unpleasant alcoholic odour of burnt sugar. The effluent of sugar mill contains considerable amount of suspended and total dissolved solids and in the present studies it varies from 1467 mgL^{-1} to 1652 mgL^{-1} in case of dissolved solids it in 689 mgL^{-1} to 786 mgL^{-1} in case of suspended solids in difficult seasons. It is an important parameter for evaluating the suitability of effluent for irrigation purposes because these solidS clog the solid pore and components of water distribution system [19]. The pH of the effluent was acidic to neutral 6.5 - 7.2 whereas well water had a pH nearby area is

7.62 – 7.9. EC of the effluent ranges from 0.82 dSm^{-1} in winter to 0.98 dSm^{-1} in monsoon season against EC 0.27-0.32 dSm^{-1} for well water.

The high value of turbidity in effluent of sugar mill led to very high BOD in different season which ranged from 686-744 mgL^{-1}. Similarly chemical oxygen demand COD of the effluent were very high in different season i.e. 11520-16520 mgL^{-1}. Whereas it was very low 214–276 mgL^{-1} in well water (Table 1-2). Very high value of turbidity, EC, BOD and COD was also reported for the effluent of Sugar Mill located in Maharashtra [20-21]. Chloride content was also high 69-89 mgL^{-1} as compared to well water. The cationic concentration of Ca^{2+}, Mg^{2+} was relatively high in the effluent than well water.

Table 1: Physico-Chemical Studies of Effluent of Sugar Mill

S. No.	Parameters	Summer	Monsoon	Winter	Mean
1.	pH	6.8	7.2	6.5	6.83
2.	Methyl orange alkalinity	120	98	112	110
3.	Acidity phenolphthalein	150	130	142	140
4.	Free CO_2	52	66	50	56
5.	Chloride Content	89	69	76	78
6.	DO	2.3	3.4	2.8	2.83
7.	BOD	744	686	728	719
8	COD	11520	12800	16520	52013
9.	Conductivity(mS/cm)	0.85	0.98	0.82	0.88
10.	Total Hardness	26,800	22420	24360	24526
11.	Permanent Hardness	19,780	17200	18420	18466
12.	Temporary Hardness	7,020	5220	5940	6060
13.	Total Solids	2156	2438	2232	2275
14.	Dissolved Solids	1467	1652	1508	1542
15.	Suspended Solids	689	786	724	733
16.	Calcium	698	582	688	553
17.	Magnesium	296	234	276	268
18.	Cr^{6+}	146	125	148	139
19.	Cu^{2+}	80.4	72.6	82.6	78.53
20.	Mn^{2+}	4.78	3.84	4.62	4.41

21.	Zn^{2+}	4.8	3.96	4.22	4.32

* All the values are in ppm except pH and conductivity

Table 2: Physico-Chemical Studies of Tube Well Water in Old Hamida near Sugarmill in Yamunanagar City

S. No.	Parameters	Summer	Monsoon	Winter	Mean
1.	pH	7.90	7.62	7.60	7.70
2.	Temperature ˚C	23.80	18.60	18.30	20.23
3.	Conductivity(mS/cm)	0.32	0.27	0.29	0.29
4.	Methyl orange alkalinity	198	234	186	206
5.	Free CO_2	20.80	21.80	26.40	23.00
6.	Total solid content	478	584	536	532.66
7.	Total dissolved solid	312	378	342	344
8	Total suspended solid	166	202	194	187.33
9.	Dissolved oxygen	7.50	7.90	7.20	7.53
10.	BOD	34.80	28.60	26.40	29.93
11.	COD	248	276	214	246
12.	Chloride content	58.60	62.00	49.80	56.80
13.	Total hardness	780	696	746	740.66
14.	Permanent hardness	436	384	412	410.66
15.	Temporary hardness	344	312	334	330
16	Calcium	182	168	162	170.66
17	Magnesium	97	86	92	91.66
18	Copper	1.84	1.62	1.78	1.74
19	Iron	1.72	1.58	1.52	1.60
20	Manganese	0.74	0.69	0.68	0.70

*All the values in the table are in ppm except pH, temperature and conductivity

Effect of Sugarmill Effluent on the Physico-chemical Properties of Soil in Yamunanagar Areas

Change in chemical properties of the soil is affected by irrigation with untreated effluent of sugar industry. pH of the soil in Yamunanagar areas where sugarmill effluent is discharged without any treatment in ranges from 7.2-7.8 in different layers. The organic carbon is generally higher in surface layer than in subsurface soil. It ranges from 6.24-9.8 gkg^{-1} in effluent irrigated soil and 1.9-3.8 gkg^{-1} in well water irrigated soil. Soil irrigated with sugar mill effluent also had high value of Na^+ and K^+ than the soil irrigated with well

water. It ranges for K+ from 426-688 kgha-1 in effluent irrigated soil and 248-355 kg ha^{-1} in well water irrigated soil samples, for Na+ it ranges 298-486 $kgha^{-1}$ for effluent treated soil and 286–426 kgha-1 for well water irrigated soil.

The surface layer of soil generally had higher concentration of these nutrients than sublayer similarly concentration of heavy metals were also found in surface layer of soils [Table 3-4]. All the values of heavy metals in the surface soils of effluent irrigated areas were above the maximum permissible limit used in Great Britain. High concentration of high metals become phytotoxic and affects plants development. Stunted growth, leaf epinasty and chlorosis are the main symptoms of heavy metal toxicity in the plants [22]. This study thus indicated that the irrigation with sugar mill effluent is responsible for the contamination of soil, plants and underground water, particularly with respect to Cr and Pb. The highest content of Cr^{6+} and Fe, Pb, Mn, Zn were reported in soil samples. All the micronutrients and heavy metals in soil samples were on the higher side and above the critical limit prescribed by Moreno et.al. [23]. The DTPA extractable micronutrients were in the order of Fe>Cu>Mn>Zn whereas the heavy metal extractability was in the order of Pb>Cr>Ni. Many of the heavy metals affinity to bind with the sulphur containing ligand and strongly bind with it and enter the plant cell causes inactivate many enzymes and disturb the metabolic process of it and cause toxicity.

Table 3: Effect of Sugar Industry Effluent on the Physico-Chemical Properties of Soil in Yamunanagar Area

S.No.	Parameters	S1	S2	S3	S4	S5
1	pH	7.6*	7.8	7.6	7.2	7.5
		7.2**	7.6	7.5	7.1	7.6
2	Electrical Conductivity	0.46*	0.38	0.45	0.32	0.46
		0.42**	0.29	0.44	0.28	0.41
3	Organic Carbon	9.42*	9.86	8.42	9.82	8.12
		8.24**	7.14	6.24	8.42	6.84
4	Available Na ($kgha^{-1}$)	376*	346	448	394	298
		384**	382	468	486	364
5	Available K ($kgha^{-1}$)	586*	688	564	672	589
		482**	598	426	610	446

* Indicate the value of soil samples from the surface tlayers 0-15 cm
**Indicate the value of soil sample from the sublayer 15-30 cm
All values are the average of three soil samples

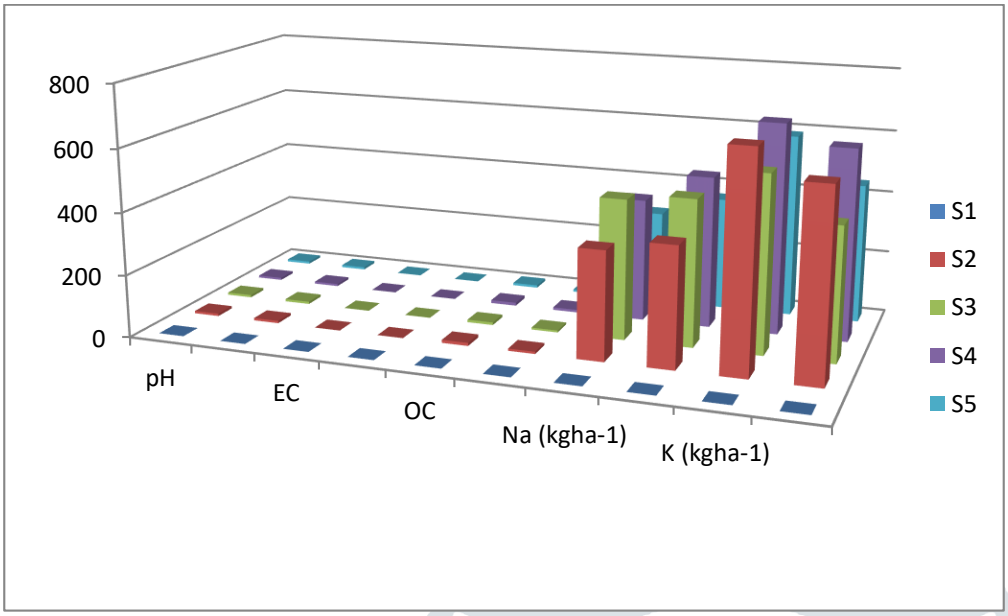

Figure: 1

Table 4: Effect of Mixed Effluents from Various Industries on the Physico-Chemical Properties of Soil in Yamunanagar City

S. No.	Parameters	S_1	S_2	S_3	S_4	S_5	S_6	S_7
1	pH	7.99*	7.4	7.44	7.82	8.2	7.9	8.0
		7.87**	7.2	7.97	7.54	7.6	7.7	7.8
2	Electrical Conductivity ($mScm^{-1}$)	0.48*	0.34	0.38	0.46	0.32	0.52	0.38
		0.42**	0.27	0.32	0.39	0.28	0.46	0.33
3	Organic Carbon (gkg^{-1})	9.87*	8.34	8.42	7.31	11.4	7.8	7.73
		6.24**	6.24	8.25	6.91	9.4	6.24	6.47
4	Available Na ($kgha^{-1}$)	376*	348	428	406	458	396	298
		394**	382	478	486	482	424	366
5	Available K ($kgha^{-1}$)	686*	504	689	586	618	672	486
		516**	428	642	482	574	610	426

*indicate the values of soil sample from the surface layer (0-15 cm)
** indicate the values of soil sample from the sub-surface layer (15-30 cm)
All the values are the average of three soil samples

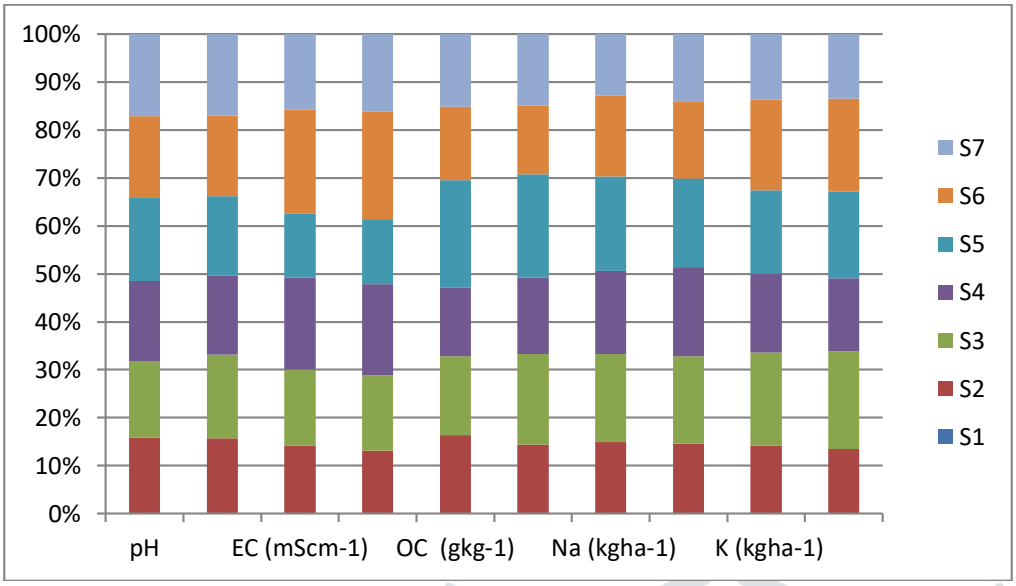

Figure: 2

Table 5: Heavy Metals Analysis of Soil from Agricultural Land Irrigated with Sugar Industry Effluent in Yamunanagar Areas

S. No.	Site	Preflowering mgkg^{-1}					
		Cr	Cu	Fe	Mn	Pb	Zn
1	S_1*	0.624	6.450	19.06	12.96	0.680	4.640
	S_1**	0.595	6.024	16.86	12.42	0.482	3.992
2	S_2*	0.968	2.642	17.82	17.24	1.068	2.890
	S_2**	0.810	2.184	15.42	14.87	9.842	2.645
3	S_3*	1.346	17.64	36.42	32.280	0.986	5.786
	S_3**	1.084	14.92	32.18	28.64	0.762	4.412
4	S_4*	0.864	7.118	48.18	24.68	0.362	5.148
	S_4**	0.712	6.872	42.24	21.16	0.216	4.364
5	S_5*	0.518	2.386	22.16	17.48	0.842	3.478
	S_5**	0.446	2.142	20.48	16.42	0.724	3.042

*indicate the values of soil sample from the surface layer (0-15 cm)
** indicate the values of soil sample from the sub-surface layer (15-30 cm)
All the values are the average of three soil samples

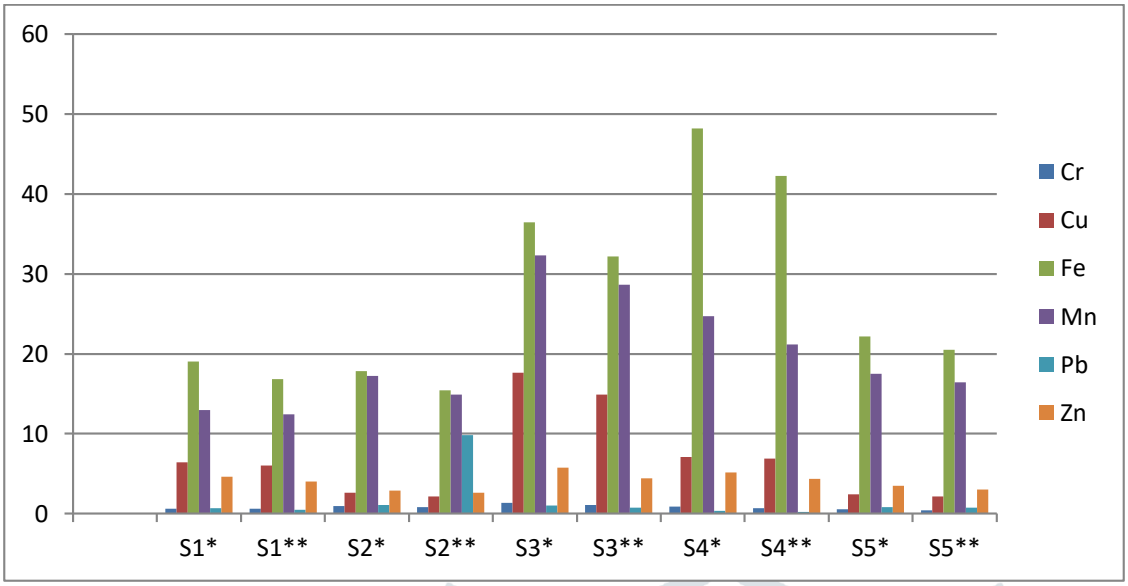

Figure: 3

CONCLUSION

From the present studies it is evident that soil of Yamunanagar areas get contaminated due to merging of various industrial effluents directly on agricultural land without any recommendable treatment may leads to accumulation of toxic metals in surface and subsurface soils. Consequently, different crops absorb and accumulation of the metals and other nutrients at greater levels, which results in easy entry into the food chain i.e. biotransfer of heavy metals. These heavy metals accumulation in the soil is also harmful to plants and animals. Sugar mill effluent discharge on the agricultural land in Yamunanagar areas is contaminated with high level of BOD, COD, TDS, Suspended solids, total hardness, heavy metals which were increasing pH, Nitrogen, Phosphorous, Sodium, Potassium and heavy metals in the soil and pose health problem if used longer period of time without giving recommendable treatment. The treated effluent did not cause any adverse effect on the Physico-chemical properties of soil but it will increase soil fertility due to presence of some useful nutrients. Therefore, recycling and reuse of Sugarmill effluent is not only helpful for conserving the water for irrigation, also the plant nutrients. Therefore it is very essential for any industrial effluent should treat properly before discharging it into any agricultural field.

ACKNOWLEDGEMENTS

The authors are thankful to Principal Guru Nanak Khalsa College Yamunanagar for providing necessary facilities to carry out the work. We are grateful to the management of Guru Nanak College and University Grant Commission for providing assistance for this work.

REFERENCE

1. Singh A.P. and Ghosh S.K., Assesment of water quality index for Yamuna Pollution Research, 18(4), 435-439 (1999).

2. Williams D.E., Vlamis J., Pukite A.H. and Corey J.E., Trace elements accumulation movement and distribution in soil pacific from massive appreciation of sewage sludge, soil Science, 12(9), 119-132(1980).
3. Khurana M.P. S., Singh M. and Navyer V.K., Assessment of heavy metal contamination in soils and plants irrigation with sewage effluents containing industrial effluents in district Amritsar Punjab, Indian J. Environ. Ecoplant, 8, 167-172(2004)
4. Jain, C.K. and Bhatia K.K.S., Physico-Chemical analysis of water and waste water, user manual UM-26, National Institute of hydrology Roorkee. (1987)
5. Datta Roy S. and Malty B.R., Pollution load of Papermill effluent discharged into the Hoogly River at Kalyani, West Bengal, Env. Eco. 1, 29-34 (1984).
6. Saraswat P.K., Tiwari R.C., Aggarwal H.P. and Kumar S., Micronutrient status of soils and vegetable crop irrigation with treated sewage water, Indian Soc. Soil sci., 53, 111-115 (2005).
7. Sharma V., Garg U.K. and Arora D., Impact of Pulp and Paper mill effluent on Physico-chemical properties of soil, Archives of applied science Research, 6(2) : 12-17(2014).
8. Leonard A. and Lanweys R.R., Carcinogenicity and mutagenicity of chromium, Mut. Res, 76, 227-239(1980).
9. Hampannavar U.S. and Shivayogimath C.B., Anaerobic treatment of sugar Industry waste water by upflow anaerobic sludge blanket reactor at ambient temperature, International Journal of Environmental Science, 1, 631-639 (2010).
10. Pande Y.N., Impact of distillery and sugarmill effluent on hydro-biology of the Paravathi lake. Ecology, Environment and conservation paper, 1, 39-42(2005).
11. Ozah P.E. and oladimeji, A. A., Effect of Nigeria dyestuff effluent on germination latency, growth and gross growth of Zeamays, Bulletein of Environmental contamination and Toxicology, 33, 215-219 (1984).
12. Fakayode P.K., Aleteration in Physico-chemical characteristics of soil irrigated with sugarmill effluent, Journal of Environmental Biology, 12, 103-109 (2005).
13. Qureshi A.L., Mahessar A.A., Leghari MEUH, et.al., Impact of releasing wastewater of sugar industries into drainage system of LBOD, Sindh, Pakistan. Int. J. Env. Sci and Dev 6:381 (2015).
14. APHA, Standard Methods of Examination of water and waste water, American Public Health Association, Washington DC, 22nd Ed., (2012).
15. Jackson, M.L., Soil chemical analysis, Prentice Hall of India Pvt. Ltd., New Delhi, 1973.
16. Beckwith, R.S., Little I.P., Journal of the Science of Food and Agriculture, 14, 15-19 (1963).
17. Walkley. A., Black I.A., Soil Sci., 37, 29-38 (1934).
18. Lindsay W.L. and Norvell. W. A., Soil Sci. Am. J., 42, 421-428 (1978).
19. Feigen A. Ravina S.J., Irrigation with treated effluent, Springer Verlag Berlin, 224 (1991).
20. Sapkal D.B., Divekar U.D., and Gujral B.B., Proceeding of the 59th Annual convention of the sugar technologists association of India Goa India, 26-28 Sept (1997).
21. Gunasekaran N., Gurugovind I., and Srockiasamy S., Proceeding of the 6th annual convention of Sugar Technologists Association of India New Delhi, 7-8 Sept (1999).
22. Mishra A. and Choudhari M.A., Effect of Salicyclic acid on Heavy metal – induced membrane deterioration mediated by lipoxygenate in rice, Biol. Plant, 42: 409-415 (1999).
23. Moreno J. L., Garcia C., Teresa H. and Miguel A. "Application of composed sewage sludge contaminated with heavy metals to an agricultural soil: Effect on Lettuce growth, Soil. Sci. Plant Nutria 43, 565-573 (1997).