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International Journal of Current Research
Vol. 8, Issue, 08, pp.36782-36786, August, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

IMPACT OF SUGAR MILL EFFLUENT ON SOIL QUALITY

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ARTICLE INFO

Article History:
Received 03rd May, 2016
Received in revised form
08th June, 2016
Accepted 29th July, 2016
Published online 31st August, 2016

Key words:

African marigold,
Heavy metals,
Properties of soil and
Sugar mill effluent.

ABSTRACT

Sugar mill effluent plays a vital role in polluting the environment which contained high pollutants. In the present study the physico-chemical properties of soil due to the effluent irrigation (before and after harvesting of African marigold with different concentration (10, 25, 50, 75 and 100%) of sugar mill effluent irrigation). Control of soil used as a tap water. The following parameters were analyzed such as pH, EC, moisture content, N, P, K, Ca, Mg, Zn, Cu, Fe and Mn. The results showed that sugar mill effluent reduced the pH and moisture content of the soil. The highest level of EC value recorded in higher concentrations of effluent irrigated soil. The sugar mill effluent significantly increased the nutrients and heavy metals in the soil with increasing of effluent concentrations. The highest agronomic performance of *Tagetes erecta* L. was found at 10% concentrations of sugar mill effluent irrigated soil. Based on the work lower concentrations of sugar mill effluent (10%) contained required amount of plant nutrient which increased soil fertility. The suggestion of the work the lower concentration (10%) of sugar mill effluent can be utilized for irrigation, which used for alternative the scarcity of water and fertilizer.

Citation: Vaithiyanathan, T. and Sundaramoorthy, P. 2016. "Impact of sugar mill effluent on soil quality", *International Journal of Current Research*, 8, (08), 36782-36786.

INTRODUCTION

Environmental pollution is a main problem of the world. Industrializations play a main role of environmental pollution. The industrial wastes have been affecting the ecosystem; especially Industries released a huge amount of waste water as effluent into nearby the water bodies which has been a major cause in reducing soil fertility and adversely affect the living organisms. Polluted water affects soil not only in the industrial area and it also affects in agricultural fields and secondary sources of pollution making in water bodies (Kisku *et al.,* 2000, Singh and Bhati 2005). The farmers used polluted water in agricultural field for the scarcity of water which contains presence of toxic chemicals and its relation to plant growth and development (Otokunefor and Obiukwu, 2005). Industrial effluents are caused water and soil pollution, which is considered as one of the most significant factors accounted for the low productivity of crops (Konwar and Jha, 2010). The effluent discharged without any treatment into the environment which contained heavy metals caused water and soil pollution.

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It changed physico-chemical properties of the soil due to the irrigation which caused the inhibited the growth and yield attributes of crops (Kumar and Arindam 2000). The fertility of soil may also be adversely affected if soil particles remain in contact with flowing effluent for a prolonged period of time as this leads to higher accumulation of salt in the soil. In addition to providing large quantities of water, some effluents contain considerable amount of essential nutrients, which may prove beneficial for plants (Swaminathan *et al.,* 1989, Adhikary 2014). The sugar industry is an agro based industry in India and its seasonal industry working for maximum of 5□6 months in one season. The sugar industry contains different type of chemicals were used during manufacturing of sugars. Large amount of water also used in during the process and as a result sugar mill released wastewater on a daily basis (Abdul Rehman 2006). Sugar mill effluent contained high amounts of BOD, COD, total solids, organic and inorganic elements which caused harmful affect the soil and crop due to irrigation (Ayyasamy *et al.,* 2008, Siva Santhi and Suja Pandian 2012, Vaithiyanathant *et al.,* 2014). The present investigation focused the physico-chemical analysis of the soil before and after harvesting of marigold grown under different concentrations of sugar mill effluent irrigation.

MATERIALS AND METHODS

Site of the experiment

Field experiments were conducted in the village kali, nearby factory area, mayiladuthurai Taluk, Nagapattinam District, Tamil Nadu.

Collection of soil samples

The African marigold grown under different concentrations (10, 25, 50, 75 and 100%) of sugar mill effluent at six separate plots and it was conducted during January 2014 to April 2014. The soil samples were collected from each plot in the African marigold field at before sowing and after harvesting. The samples were collected at 20 cm increments to a depth of 60 cm from the plots and kept in polythene bags and labeled separately. Foreign matters including dry roots, grasses and others were removed from the samples. The collected samples were air dried, crushed and sieved to pass through a 2-mm sieve. About 500 g of each sample for each depth and treatment was sealed in polyethylene bags and stored for physico - chemical analysis.

Analyses

The physico-chemical properties such as pH, electrical conductivity (EC), moisture content, available nitrogen (Subbiah & Asija 1976), available phosphorus (Jackson 1958), available potassium (Jackson 1958), available calcium (Yoshida *et al*., 1972), available magnesium (Jackson 1958), Available zinc (Piper 1966), Available copper (Piper 1966), Available iron (Piper 1966) and Available manganese (Piper 1966) of soil were estimated and recorded.

RESULT AND DISCUSSION

The physico-chemical analyses of sugar mill effluent irrigated soil (before sowing and after harvesting of African mariglod) is given in Table - 1. The following parameters such as pH, EC, moisture content, nitrogen, phosphorus, potassium, calcium, magnesium, copper, zinc, iron and manganese were analyzed and compared between control and polluted soil. Soil analysis (before sowing) shows the value of pH (6.83), Electrical conductivity (0.42 d Sm^{-1}), moisture content (19.42), Available Nitrogen (182.62 kg/ha), Available Phosphorus (21.80 kg/ha), Available Potassium (220 kg/ha), Available Calcium (19.65 mg/kg), Available Magnesium (10.20 mg/kg), Available Zinc (3.20 ppm), Available Copper (1.85 ppm), Available Iron (14.18 ppm) and Available Manganese (4.20 ppm). Soil analysis (after harvesting) showed that the minimum pH (5.92) was noticed in 100 per cent concentration of sugar mill effluent irrigated soil. The maximum level of Electrical conductivity (1.17 d Sm^{-1}) was recorded in 100% of sugar mill effluent irrigated soil. The maximum value of pH (6.92) was observed in control soil. The minimum value of Electrical conductivity (0.49 d Sm^{-1}) was observed in control soil. The maximum level of moisture content (19.28) was recorded in lower concentration (10%) of sugar mill effluent treated soil and minimum level of moisture content (12.47) was noticed in higher concentration (100%) of sugar mill effluent irrigated soil. The highest amount of Available Nitrogen (247.35 kg/ha), Available Phosphorus (39.42 kg/ha), Available Potassium (305.50 kg/ha), Available Calcium (40.52 mg/kg), Available Magnesium (11.86 mg/kg), Available Zinc (5.82 ppm), Available Copper (2.63 ppm), Available Iron (16.10 ppm) and Available Manganese (6.82 ppm) were recorded in higher concentration (100%) of sugar mill effluent irrigated plants grown soil.

The lowest content of minerals like Available Nitrogen (175.78 kg/ha), Available Phosphorus (19.92 kg/ha), Available Potassium (208.52 kg/ha), Available Calcium (14.87 mg/kg), Available Magnesium (10.36 mg/kg), Available Zinc (2.80 ppm), Available Copper (1.70 ppm), Available Iron (12.96 ppm) and Available Manganese (4.03 ppm) were recorded in control soil. The control soil was better for plant growth as well as the lower concentration (10%) of effluent irrigated soil was very good for crop production. The highest growth and yield attributes of marigold was observed in lower concentration (10%) of sugar mill effluent treated plant compared than other concentrations of effluent and control. On the other hands, gradually increased above said the parameters with increased in effluent concentration irrigated soil, which inhibited growth and yield of African marigold. Amathussalam *et al.* (2002) observed the sugar mill effluent irrigated soil contained high amounts of nutrients and heavy metals and the increased level of elements toxic to the plants.

The pH, EC, total Kjeldahl nitrogen, total organic carbon and available phosphorus, exchangeable Na, K, Ca and Mg were increased in sugar mill effluent irrigated soil (Baskaran *et al.* 2009). The pH is a significant parameter of the soil and the availability of nutrients in soil caused determines the soil pH. Adhikary (2014) reported that higher concentrations of sugar mill effluent irrigated soil had acidic in nature. The salts influenced the buffering capacity of the soil, which on dissolution release free cations, it might be the possible causes for soil dynamics. The lower concentration of sugar mill effluent irrigated soil contained cationic dynamics was very high and it decreased in higher concentrations of effluent irrigated soil. Clays, organic matter, Ca, Mg and carbonates are the component responsible for pH buffering in soils. Dhankhar and Singh (2007) said that the soil pH can influence plant growth and development. The increase of pH values in effluent treated soil could be either due to alkaline reaction of the effluent used or due to increase in soil potassium, calcium, magnesium and sodium levels. Kumar (2014) reported that the pH is a significant parameter of plant nutrition and only a particular range of pH contained presence of many nutrients for plant uptake.

A range of pH 6.0-8.2 provides predominating bacterial activity and is favorable for highest yield of crops. EC is an important factor and it used for monitoring the soil salinity. The EC values of the soil increased in higher concentration of effluent treated soil, which indicates the different salt concentration in soil. The present study showed that the EC of soil increased over control and showed a negative correlation between different concentrations of effluent in soil. Sandhu *et al.* (2007) reported that potassium salts increased EC of the soil. The increase of electrical conductivity (EC) of soil could be attributed to higher concentrations of the salts present in the effluent (Adhikary 2014, Raij *et al.* 2001, Havlin *et al.* 2013). The moisture and overall water content in soil based on the amount of water coming and going out from that soil. The moisture content of the soil depends upon the soil particle size. The present result showed a positive correlation with effluent concentration and moisture content. It may be suggested that the effluent load with higher doses in soil results as the soil particle size increase; it may reduce the soil moisture content. Sugar mill effluent influenced on soil ion exchange is one of the most important functions to facilitate occupy in soils. Mineral changes caused the ion exchange of soil that is derived from isomorphic replacement and pH dependant charge sites. It has two types of charged sites are presented such as ionization (H+ dissociation) or protonation of uncharged sites. Ionization is a negatively charged sites and protonation is a positively charged site. Nitrate is the most essential and available form of nitrogen to plants. The increase of nitrogen content in the soil due to effluent irrigation which positive associate with the soil health. The lower doses of effluent irrigated soil had availability of potassium and phosphorus might be due to increase in mineralization activity which help of increased the soil fertility and plant development. The higher concentration of effluent irrigated soil become acidified that it results in the basic cations (Mg+, Ca+, K+ and Na+) leaching gradually from the uppermost horizon. The micronutrient including nitrogen, microbial activity reduced in acidic soil, which affects plant growth (Patterson *et al.* 2008). Higher concentration of effluent have large amount of salts which deposited in the soil and it reduced the bulk density and water holding capacity of the soil due to adversely affect the soil health as well as plant. The increased of heavy metals in the soil depended upon the effluent concentrations which contained sources of pollution load. The two anions such as sulphate and chloride recorded the positive correlation with increased concentrations of effluent in soil, which contributed the salinity hazards of soil (Srivastava *et al.,* 2012). The sulphate and chlorides stimulate the plant growth at lower concentration and other hand inhibits the growth at higher concentration (Patterson *et al.,* 2008). concentrations of effluent irrigated soil showed the presence of high amount of organic compounds which affects the BOD and aeration of the soil (Kumar and Chopra 2012). Nitrate, potassium, calcium and magnesium were increased in effluent treated soil with different doses which results as a positive correlation with increased effluent concentration. Similar findings were observed by Kumar *et al.* (2010) in paper mill effluent and Magdich *et al.* (2013) in olive mill effluent. Kumar and Chopra (2014) reported that the soil contained the concentration of heavy metals such as Cd, Cr, Cu, Mn, and Zn were increased with sugar mill effluent treated. After fertigation of soil with sugar mill effluent contain the contamination factor of various heavy metals deposited in following order Mn>Cd>Cu>Zn>Pb (Kumar 2014).

The high amount of heavy metals presence in 100% sugar mill effluent and it deposited lot of metals in the soil due to irrigation. Contamination of various metals was also noticed by Krishna and Leelavathi (2002) in sugar mill effluent irrigated soil after harvesting of paddy crops. Olusegun *et al.* (2011) accounted that the heavy metals like Cd, Cu, Cr, Zn and Pb were significantly increased in the soil due to the wastewater irrigation. The effluent used continuously for irrigation as a result soil was acidic conditions, elements such as iron, aluminium, manganese and the heavy metals (zinc, copper, and chromium) become highly soluble that may be creating problems for vegetation (Roy *et al.* 2007; Samuel and Muthukkaruppan 2011; Ali *et al.* 2012). Generally effluent irrigation deposited significant amount of salts in the soil environment like phosphates, bicarbonates, chlorides of the cations sodium, calcium, potassium and magnesiums and they are increased growth and yield of crop at lower concentration but inhibit at higher concentration (Maliwal *et al.* 2004). Kumar and Chopra (2012) reported that the wastewater irrigation notably increased the concentration of various heavy metals like Cu, Zn, Cd, Ni, Cr and Pb in the soil. These heavy metals accumulate in vegetables when cultivated this soil, which harmful effect on humans and animals after intake.

Table 1. Physico-chemical analysis of different concentrations of sugar mill effluent irrigated soil (before sowing and after harvesting of African marigold)

Soil properties	Before sowing	Sugar mill effluent concentration in percentage					
		After harvesting					
		control	10%	25%	50%	75%	100%
pH	6.83	6.92	6.86	6.34	6.18	6.06	5.92
EC(dS m^{-1})	0.42	0.49	0.52	0.69	0.84	0.96	1.17
Moisture content	19.42	17.60	19.28	17.23	15.52	14.06	12.47
Available N (kg/ha)	182.62	175.78	180.40	198.65	218.94	232.63	247.35
Available P (kg/ha)	21.80	19.92	22.46	26.25	29.98	34.08	39.42
Available K (kg/ha)	220.00	208.52	224.09	246.78	268.75	282.46	305.50
Available Ca (mg/kg)	19.65	14.87	23.56	27.42	31.20	36.14	40.52
Available Mg (mg/kg)	10.20	10.36	10.68	10.86	11.08	11.32	11.86
Available Zn (ppm)	3.20	2.80	3.18	3.98	4.42	5.06	5.82
Available Cu (ppm)	1.85	1.70	1.83	1.92	2.13	2.42	2.63
Available Fe (ppm)	14.18	12.96	14.52	15.28	15.42	15.89	16.10
Available Mn (ppm)	4.20	4.03	4.68	5.25	5.76	6.28	6.82

Miller and Turk (2002) reported that potassium is a soluble cation in soil solution and it slowly displaces in soil. The potassium ions, on being absorbed by the colloids, it can displace some other ions like Ca, Mg and Na. Higher Adhikary (2014) concluded that when different concentrations of sugar mill effluent irrigation, alternation of soil quality and compositions. Higher concentrations of sugar mill effluent increase the salt content in the soil and it affects the soil health and living organisms, but lower concentrations of sugar mill effluent may be improved the fertility and nutrient status in amended soil. The mineralization of the organic materials in the effluent as well as the nutrients available in the effluent might be responsible for such an increase in the available plant nutrients (Rajannan and Oblisami 1979). The use of wastewater from other industrial sources exhibited adverse effects on fertility of the soil. Changes in chemical constituent of soil are the direct manifestation of physico-chemical properties of the effluent. The effluent is capable of altering soil fertility and such alteration plays injurious effect on the growth and yield (Rao and Kumar, 1993, Kumar and Arindam 2000, Kumar and Chopra, 2014). It is generally believed that continuous use of industrial wastewater may deteriorate the quality of the soil and make it unfit for crop production.

Conclusion

The present study concluded that the sugar industry effluent had a considerable effect on the properties of soil. The toxic metals were found to be accumulated in the soil with treated higher concentrations of effluent. Those elements may become altered the soil quality and hazard effects on crop and consumers. The lower concentration (10%) of sugar mill effluent irrigated soil contained presence of better amount of nutrients which may improve the soil health and stimulate the plant growth and yield and also reduces the risk of consumers. Finally, the lower concentration (10%) of sugar mill effluent can be uses for irrigation after appropriate dilution which alternative the scarcity of water and to improve the soil fertility. To avoid such problems of pollution, regular monitoring of the effluents quality presented in the country and their impact on soil and plant health is required in order to make use of effluent and it used in farmer for low cost of fertilizer in agriculture.

Acknowledgement

One of the authors (T. Vaithiyanathan) is acknowledged to UGC for providing to the financial support in the form of UGC research fellowship and the authors are thankful to Professor and Head, Department of Botany, Annamalai University for providing laboratory facilities to carry out these experiments.

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