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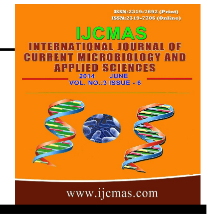

Original Research Article

Soil amendment with sugar industry effluent and its response on growth parameters of Tomato Plant (*Lycopersicon esculentum*)

S.P.Adhikary*

Department of Botany, Aska Science College, Aska-761111, Dist. Ganjam, Odisha, India
Corresponding author

A B S T R A C T

Keywords

Effluent, Growth parameters, *Lycopersicon esculetum*, Physiochemical, Soil health

Sugar industry effluent, a waste water of purely plant origin and contains large quantities of soluble organic matter and plant nutrient. The by product of sugar industry are also used as raw materials in different industry. The problem with Sugar industry effluent is excessive BOD, COD and electrical conductivity. The problem could be overcome either by the application of Sugar industry effluent after proper dilution with irrigation water or by pre plant application to give sufficient time for the natural oxidation of organic matter in soil. The study was conducted at the college campus which is 2 Kms away from Sugar Industry to determine the physiochemical parameters of sugar industry effluent treated with soil and analysed its impact on Tomato Plant. Effluent originating from sugar industry is a rich source of organic matter and nutrients like nitrogen, phosphorous, potassium, calcium, magnesium, bicarbonate and sulphur. In addition, it contain sufficient amount of micronutrients. Basing on above concept, a pot culture experiment was conducted to study the physiochemical parameters of soil with different percentage of dilution of sugar industry effluent and its impact on growth parameters of the Tomato plant. The results showed that, the physiochemical parameters of soil at different percentage of dilution of sugar industry effluent were increased (BD, OC, CO_3, HCO_3^-,Total PO_4^{-3},Total NO_3^{-2},Total K^+, Mg^{2+} ,$Ca^{2+}$$SO_4^{-2}$ and Cl^-) and decreased (pH, Soil Moisture and WHC) over control soil. The vegetative growth viz. shoot length, root length, shoot weight and root weight of 25 days old plants were highest in 25 % effluent treatment compared with control and followed by 50 %, 10 %, 75 % and 5 %. 100 % effluent treated soil exhibited a negative value of growth parameters over control. The pot experimental studies suggest the possibility to using judicious application of sugar industry effluent in agriculture and it would save costs on fertilizer and facilitate reduction in pollution load on environment.

Introduction

The Sugar Industry plays an important role in the economic development of India, but the effluents released produce a high degree of organic and inorganic pollutant in both aquatic and terrestrial ecosystem. The disposal of water based industrial effluent is a major problem faced by industries, due to generation of high volume of effluent and with limited space for land based treatment and disposal. Emerging trends of agricultural automation and reclamation of soil through irrigation of industrial effluent has been recognised as recent research.

Now there is a growing realization that the adoption of ecological and sustainable farming practices can only reserve the declining trend in the global productivity and environmental protection (Wani *et al*., 1995).Effluents are rich sources of both beneficial and harmful elements which helps for soil amendment. Since effluents are rich source of plant nutrients therefore soil provides the logical sink for their disposal. There is an increasing interest in the agricultural use of industrial wastes because of possibility of recycling valuable components such as organic matter, nitrogen, phosphorous, potassium and other nutrients and their suitability for land application (Ramasamy *et al.*,2007).In recent past years various studies have been made on the characteristics of effluent of industries and their interaction with soil and different crops(Patterson *et al.*,2010, Mohammadi *et al*., 2010, Vinod Kumar *et al*., 2010, Madan and Saxena, 2012, Rath *et al*., 2013).The present investigation focused the effect of graded doses of sugar industry effluent on soil physiochemical characteristics and its influence on growth parameters of 25 days old Tomato plant.

Materials and Methods

Sugar industry effluent collected from Aska cooperative sugar mill 3 kms away from college campus and stored in dark place. Different concentration of effluent (5%, 10%, 25%, 50%,75% and 100%) were prepared by mixing stock effluent and distilled water(v/v).Each cement pot was prepared by filling garden soil 10 Kg. All the cement pots filled with 10 Kg. of soil were irrigated with 1000 ml of sugar industry effluent of six graded does 5%, 10%, 25%, 50%.75% and 100%. 10 Kg of garden soil in cement pot with water treatment act as control for comparing the results with different dose of effluent treatments. All the treatment were replicated thrice and arranged in randomized block design in Botanical Garden of the college campus. After 10 days soil were sowed with 5 seeds of Tomato plant in each cement pot. The pots were watered with each alternate day until 25 days. After 25 days the soils and plants of respective doses and control were collected and measured the physiochemical characteristic and growth parameters. Various physiochemical characteristic by following standard methods (the soil pH was determined using glass electrode pH meter, moisture content and EC (Buurman *et al.*,1996),WHC and Bulk density (Carter,1993), $Oc,Co^{3-},Po_4^{-3},No_3^{-2},K^+,Na^+,Mg^+,Ca_2^+,So_4^{-2}$ and Cl^- (APHA,2005) and measured shoot length and weight, root length and weight (Adhikary *et al.*,2011).

Results and Discussion

Physiochemical characteristic of soil with different doses of sugar industry effluent were measured after 25 days of treatment and tabulated in table-1.pH is an important parameter for soil due to its acidity and alkalinity range which determine the availability of nutrients in soil. During the study the soil pH was increased over control in lower concentration further increase of effluent concentration in soil resulted a decreased value of pH. Dilution factor effect the alkalinity of soil pH, above 75 % dilution the soil shifted towards acidity. The buffering capacity of the soil is controlled by different weak salts which on dissolution release free cations, it might be the possible causes for soil dynamics. Cationic dynamics is higher in lower effluent concentration in soil and it decrease towards higher concentration.

The earlier studies reported that the nutrient availability enhanced at a particular pH range which increased plant growth and change in pH range from a particular limit the availability of nutrients in soil is inhibited that effected the growth and development of plant (Brady and Weil, 2005).

EC of soil increased over control and exhibited a negative correlation between doses of effluent concentration in soil and its EC values. Increased EC values towards higher effluent concentration might be due to the increased different salt concentration in soil. Sandhu *et al.,* (2007) reported that potassium salts increased EC of the soil. The moisture and overall water content in soil at a particular place is governed by the amount of water coming and going out from that soil. Soil particle size determines the moisture content and inversely proportional to each other. The present result showed a positive correlation with moisture content and effluent concentration .It may be suggested that the effluent load with higher doses in soil increase the soil particle size, it may negatively impact on soil moisture content.

Water holding capacity is related to the number, size and distribution of soil pore and quality of organic matter in soil medium. The present result observed that WHC decrease when effluent dose concentrations were increased in soil. It might be suggested the effluent salt load and organic matter increased in soil with higher doses which decreased number, size and quality of soil pore and it leads to determine the WHC. Ramulu, (2001) reported that WHC is related to soil moisture content and organic matter.

At lower concentration (5 %) increased bulk density over control, further increased dose system exhibited a positive correlation with bulk density. Bulk density decreased at 50 % and above doses, this may be attributed due to addition of organic matter which play an important role in soil physical environment. Organic carbon content of soil increased considerably with the application of different doses to soil starting from 5 % to 100 % .Increased organic content with higher doses of effluent with soil resulted in soil sickness due to poor aeration and higher BOD. The results of Vinod Kumar and Chopra,(2010), Norwal *et al.,* (1993) and Nathan, (1994) support these findings.

The bicarbonates and carbonates content of the treated soil with different doses increased over control starting from 5 % to 100 % effluent concentration. Amount of bicarbonate was increased more towards higher percentage of effluent in compared with carbonate. Soil biochemical character is changed due to carbonate and bicarbonate which increased sodicity at higher concentration while salinity with lower concentration .This findings conformity with Thompson *et al.,* (2001). Total phosphate, Nitrate and Potassium in treated soil were increased in different doses of effluent i.e. 5%, 10%, 25%, 50%, 75% and 100% over control soil. Sodium, Magnesium and Calcium in treated soil with different doses of effluent exhibited a positive correlation with increased effluent concentration. Similar findings were observed by Vinod *et al.,* (2010) in paper mill effluent.

Potassium is a soluble cation in soil solution which may displace slowly in soil. The potassium ions, on being absorbed by the colloids, it can displace some other ions such as Ca, Mg and Na (Miller and Turk, 2002).Sulphate and

Chloride are two ions noticed a positive correlation with increased doses of effluent in soil and its values. All the values of sulphate and chloride increased over control. These two anions might have contributed towards the salinity hazards associated with higher effluent doses. These findings corroborated with earlier reports of Srivastava *et al.*, (2012) in the distillery effluent and Vinod *et al.*, (2010). The present experimental results revealed that different concentration of effluent in soil (5%, 10%, 25%, 50% and 75%) enhanced different growth parameters (shoot length and weight & root length and weight) over control in 25 days old Tomato plants. Shoot length of Tomato plant was highest in 25 % effluent treatment soil over control i.e. 48 % followed by 50 %, 10 %, 75 % and 5 % treatment and their values were 33 %,26 %,19 % and 10 % respectively. 100 % effluent treated plants were showed a decreased trend of shoot length i.e. 13 % over control. Similar trend were observed in shoot fresh and dry weight but percentage of dry weight were more in compared with its fresh weight (Table-2).

Root length was increased 46 % over control in 25 % effluent treated soil but 50 %, 10 %, 75 % and 5 % effluent treatment soil were showed an increased value 34 %, 26 %,22 % and 16 % respectively.100 % effluent treatment soil exhibited deceased percentage of root length over control i.e. 11 %. The increased or decreased of growth parameters of 25 days old Tomato plant with different doses of effluent treatment to soil over control were noticed more or less similar trend .The fresh and dry weight of root were more compared with fresh and dry weight of shoot in 25 % effluent treated soil. Other treatment exhibited intermediate values (Table-2).The above results were in agreement with the findings of Chandrashekhar *et al.*,(1998) in black gram, Kaushik *et al.*, (2004) in wheat plant, Saravanamurthy and Ranjita kumari,(2005) in peanut and green gram, Ale *et al.*,(2008) in wheat and rice plants, Vijayaragavan *et al.*,(2011) in radish plant, Siva Santhi and Suja Pandian (2012) in Peanut and green gram and Narain *et al.*, (2012) in *Pisum sativum*, and Srivastava *et al.*,(2012) and Madan and Saxena,(2012) in *Solanum melongena* and Rath et al.,(2013) in Rice plant.

At appropriate effluent concentration in soil ion exchange is one of the most significant functions that occupy in soils. Ion exchange is a consequence of mineral change that is derived from isomorphic substitution and pH dependant charge sites. These charged sites are the results of ionisation (H+ dissociation) or protonation of uncharged sites; ionization results in a negative charged site and protonation a positive charged site. Both of these reactions are dependent on pH. As the pH increases, the cation exchange capacity of soil is generally greater due to an increase in the number of pH dependant charged sites. Clays, organic matter, Ca, Mg and carbonates are the component responsible for pH buffering in soils. The soil pH can influence plant growth and its biochemical turnover through the activities of soil microorganism in shape of micronutrients mobility. Nitrate is the most essential and available form of nitrogen to plants. The overall increase in nitrogen is due to that a particular effluent concentration in soil provides maximum amount of nitrogen to soil health. Graded concentration of effluent adds a significant quantity of salts to the soil such as sulphate and chlorides that stimulate the growth at lower concentration but inhibits the growth at higher concentration (Patterson *et al.*, 2008).Availability of K^+ and Po^{-4} content in the soil might be due to increase in mineralization activity of organic matter as well as nutrients present in effluent that may be responsible for increased availability of plant nutrient.

At higher effluent concentration the soil become acidified which results in a gradual leaching of basic cations i.e.(Mg^{+2},Ca^{2+},K^{+} and Na^{+}) from the upper most horizons, leaving Al^{3+} as the dominant exchangeable cation.In the acidic medium microbial activity towards organic matter and soil internal stoechiometry may be changed which decreased the availability of micronutrients including soil nitrogen. Patterson,(2008) reported that higher concentration of Na causes the decreased of the bulk density as well as water holding capacity by reducing the porosity in clay soil due to de flocculating of clay particles in presence of higher sodium content as it effects the cation exchange capacity in the soil and adversely affects the plant growth and biochemical parameters.

In present study, it has been revealed that the 25 % effluent treatment soil exhibited a better vegetative growth in 25 days old Tomato plant. The present investigation has clearly proved that the 25 % effluent treated soil may be optimum for the better growth of the plant and high biomolecular turnover rate. It could be suggested that the better growth and biomolecular content in 25 % effluent treatment may be due to the influence of combined effect of various ingredients of sugar industry effluent such as macro (N.P.K.) and micro (Ca, Mg, Mn, Fe, Zn, Cu and sulphur) nutrients, organic matter and many beneficial microbes. Lower concentration of effluent (5%, 10%, 25%, 50% and 75%) in soil exhibited a better growth in compared to control. Maximum growths of plant were noticed in 25 % followed by 50 %, 10 %, 75 % and 5 % respectively.100 % effluent treatment with soil showed retardation of growth in compared with control. Different concentration of effluent were highly effected the plant growth due to the excess amount of organic matter, micro and macro nutrients. Lower concentration of (5%, 10%, 25%, 50% and 75%) effluent the growth parameters were higher than that of control plants, which may be taken as an indication of beneficial range, while for higher concentration (100 %) of effluent, a decreasing trend was observed, which confirms the toxic effect of this effluent to Tomato plants. At lower concentration of effluent treatment soil may be lower bulk density and increased hydraulic conductivity. This can be attributed to improve in total porosity and aggregate stability in the soils due to addition of organic matter which play an important role in improving soil physical environment. Application of higher concentration (100 %) of effluent reduced the hydraulic conductivity of soils due to pore clogging by suspended solids. Higher concentration of effluent (100 %) with high organic matter resulted soil sickness due to poor aeration and high BOD. 100 % of effluent in soil may be containing above critical concentration of heavy metal of respective metal concentration which influence the plant growth retardation. Plant growth retardation changes the bimolecular content and its turnover rate.

The present study concluded that the sugar industry effluent had a considerable effect on the properties of soil. It decreased the pH, moisture content, WHC and Bulk density whereas EC, Organic carbon, Co^{3-}, HCo^{3-},Po_4^{-3},No_3^{-2},K^{+},Na^{+},Mg^{2+},Ca^{2+},So_4^{-2} and Cl^{-} values were increased over control.

Table.1 Physiochemical characterstic of soil after treatment of different concentration of Aska sugar industry effluent

Parameters	Effluent concentration (%)						
	Control (Water treatment)	5%	10%	25%	50%	75%	100%
pH	7.18 ± 0.14	7.48 ± 0.16	7.23 ± 0.11	7.19 ± 0.09	7.11 ± 0.08	6.65 ± 0.12	6.12 ± 0.14
EC (dsm^{-1})	1.96 ± 0.11	2.17 ± 0.18	2.28 ± 0.15	2.41 ± 0.13	2.56 ± 0.12	2.74 ± 0.21	3.12 ± 0.16
Soil moisture (%)	38.62 ± 0.24	41.18±0.21	40.32±0.26	39.58±0.32	38.76 ± 0.23	34.35 ± 0.34	31.24 ± 0.28
WHC (%)	46.21 ± 0.27	45.86±0.18	43.3 ± 0.22	41.54±0.21	38.35 ± 0.25	34.23 ± 0.19	28.16 ± 0.23
BD (gm cm^{-3})	1.38 ± 0.12	1.40 ± 0.15	1.39 ± 0.13	1.38 ± 0.18	1.37 ± 0.17	1.31 ± 0.11	1.28 ± 0.21
OC (mg kg^{-1})	1.47 ± 0.09	5.61 ± 0.12	6.87 ± 0.26	9.32 ± 0.24	10.82 ± 0.28	13.64 ± 0.34	18.5 ± 0.26
CO_3^{-2} (mg kg^{-1})	140.06±0.32	143.23±0.29	149.11±0.24	158.38±0.25	163.31±0.26	186.64±0.32	204.11±0.21
HCO_3^- (mg kg^{-1})	263.14±0.21	311.23±0.26	389.45±0.23	461.74±0.18	510.83±0.15	696.24±0.26	830.34±0.22
Total PO_4^{-3} (mg kg^{-1})	42.41±0.27	51.82 ± 0.19	60.91±0.18	72.23±0.23	79.63 ± 0.25	90.34 ± 0.19	112.62±0.21
Total NO_3^{-2} (mg kg^{-1})	51.34±0.25	54.61 ± 0.23	58.92±0.27	62.36±0.21	71.56 ± 0.28	86.65 ± 0.29	90.45 ± 0.22
Total K^+ (mg kg^{-1})	136.82±0.34	138.41±0.42	142.53±0.32	146.75±0.46	152.91±0.41	162.83±0.28	209.74±0.35
Na^+ (mg kg^{-1})	28.23 ± 0.21	30.62 ± 0.31	36.24±0.26	41.55±0.22	52.82 ± 0.21	63.76 ± 0.27	82.54 ± 0.24
Mg^{2+} (mg kg^{-1})	2.68 ± 0.11	3.23 ± 0.09	3.94 ± 0.16	4.63 ± 0.14	5.76 ± 0.15	6.81 ± 0.18	8.32 ± 0.13
Ca^{2+} (mg kg^{-1})	18.13 ± 0.19	20.63 ± 0.12	26.34±0.13	32.54±0.14	41.64 ± 0.08	62.36 ± 0.23	90.06 ± 0.22
SO_4^{-2} (mg kg^{-1})	61.38 ± 0.23	64.94 ± 0.32	73.66±0.29	89.15±0.26	96.37 ± 0.23	112.45±0.34	136.34±0.38
Cl^- (mg kg^{-1})	89.82 ± 0.31	96.38 ± 0.36	119.46±0.34	142.1±0.29	168.36±0.28	206.8 ± 0.37	276.1 ± 0.35

Table.2 Effect of different concentration of sugar industry effluent on 25 days old Tomato plant's (*Lycopersicum esculentum L*) vegetative growth parameters.
(Each value is mean of 5 samples ± SEM)

Treatment (ml/kg)	Vegetative growth parameters																	
	Shoot length(cm)			Shoot fresh wt.(gm)			Shoot dry wt. (gm)			Root length (cm)			Root fresh wt.(gm)			Root dry wt. (gm)		
	Shoot Length	Diff. from Control	% of increase over control	Fresh wt.	Diff. from Control	% of increase over control	Dry wt.	Diff. from Control	% of increase over control	Root Length	Diff. from Control	% of increase over control	Fresh wt.	Diff. from Control	% of increase over control	Dry wt.	Diff. from Control	% of increase over control
Control	5.8 ± 0.16	-	-	7.2 ± 0.18	-	-	0.68 ± 0.08	-	-	3.6 ± 0.19	-	-	0.45 ± 0.15	-	-	0.09 ± 0.08	-	-
05 %	6.4 ± 0.14	0.6	+ 10	8.1± 0.16	0.9	+ 9	0.80 ± 0.05	0.12	+ 18	4.17 ± 0.16	0.57	+ 16	0.53 ± 0.16	0.08	+ 18	0.108 ± 0.06	0.018	+ 21
10 %	7.3 ±0.13	1.5	+ 26	9.0± 0.13	1.7	+ 24	0.88 ± 0.06	0.20	+ 29	4.53 ± 0.18	0.93	+ 26	0.59± 0.19	0.14	+ 32	0.120 ± 0.07	0.030	+ 33
25 %	8.6 ±0.12	2.8	+48	10.1± 0.17	2.9	+ 40	1.06 ± 0.06	0.38	+ 56	5.25 ± 0.14	1.65	+ 46	0.66± 0.17	0,21	+ 48	0.135 ± 0.05	0.045	+50
50 %	7.7±0.19	1.9	+33	9.3± 0.14	2.1	+ 29	0.96 ± 0.06	0.28	+ 42	4.82 ± 0.17	1.22	+ 34	0.61± 0.18	0.16	+ 36	0.125 ± 0.04	0.035	+39
75 %	6.9 ±0.18	1.1	+ 19	8.4 ±0.11	1.2	+ 17	0.84 ± 0.02	0.16	+ 24	4.39 ± 0.12	0.79	+ 22	0.55± 0.14	0.10	+ 24	0.114 ± 0.06	0.024	+ 27
100 %	5.0 ±0.11	- 0.8	- 13	6.5 ± 0.09	-0.7	- 10	0.56 ± 0.03	- 0.12	- 18	3.21 ± 0.13	- 0.39	- 11	0.38 ± 0.13	- 0.07	- 16	0.073 ± 0.03	- 0.017	- 19

Micronutrient of sugar industry effluent contributed a significant change in the quality and affected the natural composition of the soil. Alternation of soil quality and composition with treatment of different doses sugar industry effluent may be improved the fertility and nutrients status in amended soil. All diluted concentration of effluent were exhibited a better nutrient accumulation over control.

This experimental result noticed that 25 % effluent dilution showed better growth in 25 days Tomato plant followed by 50 %, 10 %, 75 % and 5 %. Thus application of sugar industry effluent to the agricultural field, as an amendment, might be a viable option for safe disposal of effluent with concomitant improvement in physical properties and micronutrient status of soil. Based on these results the farmers around the locality should be properly educated about the beneficial effect of sugar industry effluent in agriculture and it would save costs on fertilizer and facilitate reduction in pollution load on environment.

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