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REGULAR ARTICLE

SUGAR MILL EFFLUENT TOXICITY IN CROP PLANTS

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SUMMARY

The laboratory experiments were conducted to know the effect of different concentrations of sugar mill effluent on seed germination, biochemical content of crops. The experiment was conducted with the both crops at different concentrations of sugar mill effluent. The growth parameters such as germination percentage, seedling length, lateral roots, dry weight, were measured at 7th DAS. After sowing (DAS) the pigment content viz., chlorophyll a, chlorophyll b, total chlorophyll, carotene, sugar, starch, amino acid, protein contents were analysed at 7th day. All morphological growth parameters, biochemical contents, were found to increase at 5% effluent concentration and it decreased from 10% effluent concentration onwards. So these results reflect that the sugar mill effluent is toxic to crop and it can be used for irrigation purpose after a proper treatment with appropriate dilution.

Keywords: Sugar mill effluent, *Eleusine coracana*, *Vigna mungo*, Biochemicals.

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1. Introduction

In arid and semi-arid regions, the rational use of water in agriculture is of fundamental importance for obtaining good profits and reducing water use confects. Most of our water resources are gradually becoming polluted by addition of huge amounts of sewage, industrial effluents. These effluents contain toxic materials with varying properties from simple nutrients to highly toxic substances. The discharge of industrial effluents with varying amounts of pollutants has altered the water quality. There are nearly 436 sugar mills in India which play a major role in rural economy of our country. During sugar production, the mills release a large amount of waste water containing various physical and chemical agents. They are discharged into land or nearby water bodies. The polluted water is being used for irrigation by nearby farmers. It is necessary to study the impact of these effluent on crop system before they are recommended for agricultural irrigation. Several studies have been done on the impact of various industrial effluents on various crops (1, 2, 3 and 4). Against this back drop, a laboratory experiment was conducted to find out the effect of different concentrations (0-100%) of sugar mill effluent on biochemical contents of blackgram (*Vigna mungo*) and ragi *Eleusine coracana* (L.).

2. Materials and methods

Collection of sugar mill effluent

The effluent sample was collected from the outlet of M.R.K. Co-Op. sugar mill Sethiathope in Cuddalore district, Tamilnadu, India. It is various physico-chemical characteristics were analysed using standard method (5). The effluent stored at 5°C during storage period to avoid changes in its characteristics. These concentrations were selected on the basis of our preliminary studies showing that 10% (v/v) concentrations in general declines all parameters upto 50%.

Seed materials

Blackgram (Vigna mungo (L.) Hepper. var. CO-5) and ragi (Eleusine coracana (L.) Gaerth. var. CO-13) were procured from Tamil Nadu, Agricultural University (TNAU) Coimbatore.

Germination studies

For germination tests 50 seeds of each crops were surface sterilized with 0.02% mercuric chloride (HgCl2) for two minutes. Washed with running tap water, 50 seeds were placed equidistantly in sterilized peteridishes lined with filter papers. The seeds in the peteridishes were moistered with 10 ml of each effluent concentrations of control set was treated with distilled water. The emergence of radicle was taken as the criterion for germination. Each treatment was maintained as triplicate.

Biochemical analysis

The chlorophyll and carotenoid contents of seedlings were estimated by (6) and (7), respectively sugar (8), starch (9), free amino acids (10) and protein (11).

Statistical analysis

The resulted were expressed probability values of less than 0.05 were considered significant. Analysis of variance (ANOVA) raw effluent with various concentration as independent variable using statistical software.

3. Results and discussion

Physico-chemical properties of sugar mill effluent are given in Table (1). The analysis of sugar mill effluent showed that it is acidic in nature with dull white in colour. It contained high amounts of suspended and dissolved solids. It showed a high value of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The presence of considerable amounts of calcium, magnesium, chloride, sulphate, fluoride, nitrate and silica, were also noticed in the effluent. This conformity with the earlier findings of (12), (13), (14) and (4).

Table 1.Physico-chemical analyses of sugar mill raw effluent

Properties	Raw effluent	Purpose I.S.I. standard
Physical properties		
Colour	Brown	Colourless
Odour	Decaying smell	Odourless
Temperature	36	40
Suspended solids	520	100
Dissolved solids	2860	100
Chemical properties		
pH	6.17	5.5-9.0
BOD	3240.0	500
COD	5326.0	250
Chloride	900.0	600
Sulphate	298.95	2100
Calcium	400.0	1000
Oil and Greece	15.0	30

All parameters are expressed in mg/l except, pH, colour, odour and temperature

The germination percentage decreased gradually with an increase in effluent concentrations. The seeds showed cent per cent germination at 5 per cent concentration of effluent on seventh day for both plants respectively (Table 2). The higher concentration of effluent reduced the germination of seeds. The presence of excessive dissolved solids and high BOD values may be responsible (15) in sago effluent and also be attributed to acidic pH associated with chlorides compounds in the effluent (16).

Biochemical analysis

The chlorophyll is one of the important biochemical content which is used as an index of production capacity of the plant. The chlorophyll a, b, total chlorophyll and carotenoid content increased at lower concentration of sugar mill effluent (Table 3).

Table 2. Effect of sugar mill effluent on germination, seedling length, lateral roots and dry weight of *Vigna mungo* and *Eleusine coracana* seedlings (7th day)

Effluent con. in %	Blackgram				Ragi			
	Germination %	Seedling length (cm)	Lateral roots (No)	Dry weight (g)	Germination %	Seedling length (cm)	Lateral roots (No)	Dry weight (g)
Control	97.00	24.16	7.83	0.037	96.00	12.63	7.50	0.034
5	99.00 (2.06)	25.66 (6.20)	8.33 (6.38)	0.043 (16.21)	98.00 (2.08)	13.70 (8.47)	8.83 (17.73)	0.039 (14.70)
10	98.00 (1.03)	24.53 (1.53)	8.16 (4.21)	0.041 (10.81)	97.00 (1.04)	13.03 (3.16)	8.16 (8.8)	0.037 (8.82)
25	87.00 (-10.30)	22.36 (-7.45)	7.33 (-6.38)	0.035 (-5.40)	90.00 (-6.28)	11.66 (-7.68)	7.16 (-4.53)	0.032 (-5.88)
50	75.00 (-22.68)	17.73 (-26.61)	6.00 (-23.37)	0.031 (-16.21)	80.00 (-16.66)	9.46 (-25.09)	6.00 (-20.00)	0.028 (-17.64)
75	60.00 (-38.14)	13.26 (-45.11)	4.50 (-42.52)	0.027 (-27.02)	61.00 (-36.45)	8.33 (-34.04)	4.50 (-40.00)	0.025 (-26.47)
100	48.00 (-50.51)	9.63 (-60.14)	2.16 (-72.41)	0.024 (-35.13)	49.00 (-48.95)	6.53 (-48.29)	3.06 (-59.20)	0.021 (-38.23)
F**	123.48	116.26	71.60	149.00	113.68	92.62	50.92	127.42
CD	1.726	1.470	0.508	1.305	1.408	0.970	1.330	1.300

F values for the variance between treatment; CD = 0.05 level; ** Significant at 1% level; Figure in parentheses are % over control

Table 3. Effect of sugar mill effluent on chlorophyll a, b, total chlorophyll and carotenoid content of *Vigna mungo* and *Eleusine coracana* (mg/g fresh weight) seedlings (7th day)

Effluent con. in %	Black gram				Ragi			
	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotene	Chlorophyll a	Chlorophyll b	Total chlorophyll	Carotene
Control	0.756	0.684	1.440	0.478	0.761	12.63	1.456	0.486
5	0.823 (8.86)	0.746 (9.06)	1.569 (8.95)	0.541 (13.17)	0.834 (9.59)	13.70 (8.47)	1.593 (9.40)	0.563 (15.84)
10	0.784 (3.70)	0.710 (3.80)	1.494 (3.75)	0.493 (3.13)	0.790 (-3.81)	13.03 (3.16)	1.522 (4.53)	0.510 (4.93)
25	0.712 (-5.82)	0.653 (-4.53)	1.365 (-5.20)	0.450 (-5.85)	0.723 (-4.99)	11.66 (-7.68)	1.396 (-4.12)	0.462 (-4.93)
50	0.645 (-14.68)	0.602 (-11.98)	1.247 (-13.40)	0.407 (-14.85)	0.652 (-14.32)	9.46 (-25.09)	1.267 (-12.98)	0.423 (-12.96)
75	0.579 (-23.41)	0.547 (-20.02)	1.126 (-21.80)	0.362 (-24.26)	0.584 (-23.25)	8.33 (-34.04)	1.138 (-21.84)	0.376 (-22.63)
100	0.507 (-32.93)	0.486 (-28.94)	0.993 (-31.04)	0.316 (-33.89)	0.513 (-32.58)	0.492 (-29.20)	1.005 (-30.97)	0.325 (-33.12)
F**	95.58	70.58	101.44	121.96	65.73	82.17	60.40	63.89
CD	0.362	1.360	1.357	1.50	3.80	2.20	0.451	2.40

F values for the variance between treatment; CD = 0.05 level; ** Significant at 1% level; Figure in parentheses are percentage over control

Table 4 Effect of sugar mill effluent on sugar, starch, amino acid and protein content (mg/g fresh weight) of *Vigna mungo* seedlings (7th day)

Effluent	Sugar		Starch		Amino acid		Protein	
con. in %	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
Control	3.296	3.453	2.636	3.522	2.596	3.464	14.736	15.426
5	4.272 (29.61)	4.346 (25.86)	3.984 (51.13)	4.647 (31.94)	3.754 (32.20)	4.526 (30.65)	15.693 (6.48)	16.734 (8.47)
10	3.634 (10.25)	3.564 (3.21)	3.243 (23.02)	3.826 (8.63)	3.436 (32.35)	4.287 (23.75)	15.124 (2.63)	16.262 (5.41)
25	3.112 (-5.58)	3.355 (-2.83)	2.554 (-3.11)	3.342 (-5.11)	2.389 (-7.97)	3.253 (-6.09)	14.123 (-4.15)	15.034 (-2.54)
50	2.586 (-21.54)	2.694 (-21.98)	2.326 (-11.76)	2.826 (-19.76)	2.076 (-20.03)	3.102 (-10.45)	13.612 (-7.62)	14.383 (-6.76)
75	2.114 (-35.86)	2.223 (-35.62)	1.835 (-30.38)	2.344 (-33.44)	1.753 (-32.47)	2.792 (-19.39)	12.569 (-14.70)	13.145 (-14.78)
100	1.635 (-50.39)	1.784 (-48.33)	1.326 (-49.69)	1.832 (-47.98)	1.424 (-45.14)	2.360 (-31.87)	10.563 (-28.31)	11.624 (-24.64)
F**	105.84	64.98	90.45	76.81	85.30	95.40	85.41	91.87
CD	0.976	0.893	1.348	1.125	1.158	1.062	0.957	1.308

F values for the variance between treatment; CD = 0.05 level; ** Significant at 1% level; Figure in parentheses are percentage over control

Table 5 Effect of sugar mill effluent on sugar, starch, amino acid and protein content (mg/g fresh weight) of *Eleusine coracana* seedlings (10th day)

Effluent	Sugar		Starch		Amino acid		Protein	
con. in %	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
Control	2.936	3.226	3.846	4.632	1.898	2.696	13.824	14.956
5	3.965 (35.04)	4.118 (27.65)	4.912 (27.71)	5.746 (24.05)	2.764 (45.62)	3.984 (47.77)	14.626 (5.80)	15.784 (5.53)
10	3.632 (23.70)	3.724 (15.43)	4.756 (23.66)	5.524 (19.25)	2.586 (36.24)	3.692 (36.94)	14.284 (3.32)	15.138 (1.21)
25	2.824 (-3.81)	2.936 (-8.98)	3.696 (-3.90)	4.384 (-7.16)	1.754 (-7.58)	2.565 (-4.85)	13.432 (-2.83)	14.396 (-3.74)
50	2.346 (-20.09)	2.432 (-24.61)	2.864 (-25.53)	3.322 (-28.28)	1.432 (-24.55)	2.258 (-16.24)	12.521 (-9.42)	13.424 (-10.24)
75	1.892 (-35.55)	1.946 (-39.67)	2.346 (-39.00)	2.768 (-40.24)	1.228 (-35.30)	2.046 (-24.10)	11.422 (-17.37)	12.521 (-16.28)
100	1.324 (-54.90)	1.435 (-55.51)	1.584 (-58.81)	1.876 (-59.49)	1.024 (-46.04)	1.838 (-31.82)	10.384 (-24.88)	11.294 (-24.48)
F**	73.06	60.55	86.41	78.63	132.13	62.53	42.19	67.81
CD	1.029	0.892	1.066	1.066	0.866	1.288	0.802	0.828

F values for the variance between treatment
CD = 0.05 level
** Significant at 1% level
Figure in parentheses are percentage over control

It may be due to the decrease in the chemical concentrations to an optimum level on the dilution of the effluent the increase in carotenoid content might be due to enhanced influence of nitrogen and other organic elements present in the effluent (17). In cane of *Cicer arietinium* after exposesure of distillery effluent probably because of influx of nutrient concentrations, which promote the chlorophyll contents (18).

Reduction in chlorophyll content induced by effluent may be associated with mineral ions. Some of the possible reasons for the decrease in chlorophyll content may be the formation of enzyme such as chlorophyllase which is responsible for chlorophyll degradation (19), (20) and (21). Iron, magnesium, potassium, zinc and copper are essential for the synthesis of chlorophyll (22). The increase in the chlorophyll content at lower concentration of the effluent might be due to the favourable effect of nitrogen and other elements which are present in their optimum quantities. Presence of magnesium and potassium in their optimum quantities in the lower concentration of the effluent which are required for biosynthesis of pigment.

The increase in total sugar and starch content of root and shoot of both blackgram and ragi seedlings were observed at 5 per cent concentration of sugar mill effluent (Tables 4 and 5). The sugar content showed decreasing trend at higher concentrations of the effluent. The effect may be due to transportation of most of the nitrogen absorbed by the plants (23 and 17). The another view for the decrease of sugar content at higher concentration of the effluent might be due to the excessive nutrient uptake that caused imbalance and eventually cut to depletion of carbohydrate reserve (24 and 25).

The increase in the amount of soluble, reducing sugar and starch might be either due to inhibition in starch synthesis from hexose or stimulation of starch hydrolysis (26). The reduced amount of sugar in the plants treatment with higher concentrations of the effluent might be due to the utilization of the sugars in metabolic activity in order meet stress conditions (27) and also the decreasing sugar content may be due to the cellulose levels in plant cell walls at higher concentration the cell walls showed the lower level of cellulose due to the presents of minerals (15).

Decrease in free amino acids at high salinity decrease in amino acid at higher concentrations can be attributed to the inhibitory effect of the effluent on protease activity (28 and 29). The protein content of blackgram and ragi. It might also be attributed to greater absorption and assimilation of potassium and nitrogen, which play a vital role in protein synthesis (30). The presence of high concentration of various cations and anions, in the effluent suggest the charges induced by the effluent stress (31 and 32).

The higher concentration of sugar mill effluent decreased the protein content of both crops. The reduction in the rate of nitrogen absorption and amount of nitrogen present in the plants, the total physiological activities were found to decrease resulting in gradual reduction in protein content of the plants treated with higher concentrations of the effluent (33). The significant increase in the protein content of pea, plant might be due to the potassium and nitrate in their optimum quantity present in the lower concentration of the effluent (34).

Finally the article concluded that with results the higher concentration of effluent act as a stress at the same time lower concentration effluent enhance the plant physiological and morphological activity, by means of presence of required amount of nutrient present in lower concentration. So, we can use the lower concentration of effluent for getting higher yield of crop plants.

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