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Ameliorating effect of vermicompost and cow dung compost on growth and biochemical characteristics of *Solanum melongena* L. treated with paint industrial effluent

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ABSTRACT

The ameliorating effect of vermicompost and cow dung compost on growth and biochemical characteristics of Solanum melongena treated with paint industrial effluent was evaluated in this study. The color and odor of the effluent samples, physical and chemical parameters like pH, EC, TDS, TS, EC and heavy metals were analyzed. The effluent contained sulphates, chlorides, phosphates, dissolved solids and other pollutants in higher amounts. The effect of effluent with water, vermicompost and cow dung were studied on shoot length, root length, leaf area, fresh weight, dry weight and biochemical parameters like Chlorophyll a, Chlorophyll b, Total Chlorophyll and Carotenoids of S. melongena. It was noted that the length of the root and shoot, fresh and dry weight of the plant was considerably decreased with increase in concentration of the effluent. There was a gradual increase in all the parameters except the leaf area with increase in effluent concentration with vermicompost and cow dung. There was no change in the chlorophyll content on 80% effluent with vermicompost when compared to the control, whereas reduction in the carotenoids content was noted in 80% effluent with vermicompost.

Keywords: Vermicompost, Cow dung compost, Industrial effluent, *Solanum melongena* L., Chlorophyll, Carotenoids

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INTRODUCTION

Industrial development has been the major cause of environmental pollution. The fertility of the soil is also affected by the waste water emanating from the industries. The rapid increase in the chemical based industries including painting industries is a major cause for pollution of air, water and soil. Water pollution is highly enriched by over productive biotic community, such as river or lake with nutrients from sewage or fertilizer (cultural eutrophication), or a body of water poisoned by toxic chemicals which eliminate living organisms or even exclude all forms of life **[1]**.

Effluents are waste products in liquid form released by different industries such as petro-chemical complexes; fertilizer factories; oil refineries; pulp, paper, textile, sugar and steel mills, tanneries, distilleries, coal wateriest, synthetic material plant for drugs, fibers, rubbers, plastics, painting industries, etc. The industrial waste of these industries includes metals (Copper, Zinc, Lead, Mercury, etc.), detergents, petroleum, acids, alkali, phenols, carbamides, alcohols, cyanide, arsenic, chlorine and many other inorganic and organic toxicants. All of these chemicals of industrial waste are toxic to animals and many cause death or sub-lethal pathology to the liver, kidneys, reproductive systems, respiratory systems or nervous systems in both invertebrate and vertebrate aquatic animals **[2]**.

It also had the ability to withstand varying adverse site conditions, i.e. high pH, salinity, solidity, shallow soil depth, etc. Kannan and Upreti **[3]** reported effects on germination and growth by treated and untreated distillery effluents. Sugar factory effluent has been shown to stimulate physiological and biochemical parameters of *Gossypium hirsutum* L. **[4]** but it inhibited the growth of plants such as *Zea mays*, *Vigna radiata*, and aquatic plants such as *Eichhornia crassipes* and *Pistia stratiotes* **[5]**. Undiluted mint effluents also caused marked inhibitory effects on the growth of *Vigna unguiculata* **[6]**.

Cow dung is the undigested residue of herbivorous matter which has passed through the animal's gut. The resultant faucal matter is rich in minerals. Color range from greenish to blackish, often darkening in color soon after exposure to air. Cow dung (usually combined with soiled bedding and urine) is often used as manure (agriculture fertilizer). Vermicompost is the product or process of composting utilizing various species of worms, usually red wigglers (*Eisenia foetida* or *Eisenia andrei*), worms, and earthworms to create a heterogeneous mixture of vegetable or food waste, bedding materials, and vermicast. It contains higher level of organic matter, organic carbon, total and available N, P, K and micronutrients, microbial and enzyme activities. Tomati *et al*. **[7]** and Rehman et al. **[8]** also reported that vermicompost contains higher amount of humid acid content and biologically active substances such as plant growth regulators.

Long term use of inorganic fertilizers without organic supplement damages the soil physical, chemical and biological properties and causes environmental pollution **[9]**. Organic manures not only act as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in the soil, influence structure, nutrients turnover and many other related physical, chemical and biochemical parameters of the soil **[9]**. *Solanum melongena* L. is an agronomically important non-tuberous Solanaceous crop grown primarily for its large oval fruit. In popular medicine, this plant is indicated for the treatment of several diseases, including diabetes, arthritis, asthma and bronchitis.

This study deals with the treatment of *Solanum melongena* L., with different concentrations of industrial effluent, vermicompost and cow dung compost for consecutive ten days.

MATERIALS AND METHODS

Effuluent Sample and Preservation

The industrial effluent sample was collected from DhyanArt, West Tambaram, Chennai. The plastic container for sample preservation was thoroughly cleaned by rinsing with 8M HNO_3 followed by repeated washing with distilled water. The containers were rinsed thrice with water before collection of the samples for preservation. The parameters like color and odor were determined after collection of the sample.

Measurement of Waste Water Quality Parameters

The industrial effluent sample was collected and the following water quality parameters were measured within a period of 72 h. The sample for analysis was preserved as per the standard recommended procedure **[10]**.

Physio-chemical Parameters

Hydrogen ion concentration of the effluent was measured using digital pH metre. The temperature of the effluent sample was noted at the time of sampling using precision of thermometer (0.1 °C accuracy). The electrical conductivity was measured using biochemical conductivity bridge model M70.

The electrical conductivity of the solution was calculated using the below formula:

$$\text{Electrical conductivity} = \text{Specific conductance} \times 0.65 \text{ cm (micromhos)}$$

Physico-chemical parameters, such as biological oxygen demand (BOD), total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), chloride, alkalinity, total hardness, calcium, magnesium, sulphate, phosphate and total iron, were measured using standard methods **[11]**.

Growth Parameters
Percentage of Germination
Number of seeds germinated on the seed tray was counted on the third day after sowing. The percentage of germination was calculated as per the following formula:

$$\text{Percentage of germination} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

1. Shoot length, root length and leaf area
The shoot and root length of randomly selected seedling's shoot and root after 10 days treatment was measured for both the control and experimental plants with the help of meter scale. The leaf area was measured from randomly selected control and experimental plants by using graph sheets.

2. Determination of fresh weight
Selected seedlings were harvested without causing any damage or wounds, dapped and weighed.

3. Determination of dry weight
Fresh individual undamaged seedlings were kept in an oven for a night at 80˚C and weighed individually.

Biochemical parameters
1. Extraction and estimation of chlorophyll
One gm fresh leaves of *S. melongena* were cut into small pieces and homogenized in a mortar with excess acetone, with a pestle. The supernatant was then filtered on a Buchner funnel through Whatman No. 42 paper. Sufficient quantity of 80% acetone was added and the extraction procedure was repeated. The brie was transferred with acetone until it becomes colorless. The filtrates were pooled and made up to 100 mL in a volumetric flask. Five milliliters of the extract was transferred into a 50 mL volumetric flask and diluted with 80% acetone.

Absorbance was measured at 645 and 663 nm for the determination of chlorophyll *a*, *b* and total chlorophyll. For routine measurements of total chlorophyll, the absorbance of the extract at 652 nm was measured using a light path of 1 cm. By using the specific absorption coefficients for chlorophyll *a* and *b* at 645 and 663 nm in 80% acetone, the following simultaneous equation was used for measuring chlorophyll concentrations.

i. A_{645} = 82.04 Chlorophyll *a* + 9.27 Chlorophyll *b*
ii. A_{663} = 16.75 Chlorophyll *a* + 45.6 Chlorophyll *b*
iii. Chlorophyll *a* (mg/L) = 12.7 A_{663} – 2.69 A_{645}
iv. Chlorophyll *b* (mg/L) = 22.9 A_{645} – 4.68 A_{663}
v. Total Chlorophyll (mg/L) = 20.2 A_{645} + 8.02 A_{663}

2. **Estimation of carotenoids**
Carotenoids were calculated from the supernatant by the method of Arnon **[12]** by using the formula:

$$\text{Carotenoids} = A_{480} + (0.11453 + A_{663}) - (0.6377 + A_{645})$$

RESULTS AND DISCUSSION

The irrigated agriculture in countries like India demands large amounts of water and faces the serious challenge to increase or at least sustain agricultural production while coping with less and/or lower quality water. Over the years, the severe shortage of water, primarily in the arid and semi-arid regions, has promoted the search for extra sources currently not intensively exploited. Treated wastewater is now being considered and used in many countries throughout the world, as a new additional, renewable and reliable source of water, which can be used for agricultural production. By releasing freshwater sources of potable water supply and other priority uses, treated wastewater reuse makes a contribution to water conservation and expansion of irrigated agriculture, taking on an economic dimension. It also solves disposal problems aimed at protecting the environment and public health and prevents surface water pollution by the direct discharge of pollutants into inland and coastal waters. In this study, the treatment of, *Solanum melongena* L., with different concentrations of industrial effluent, vermicompost and cow dung compost for consecutive ten days was evaluated.

Physico-chemical Characteristics of the Painting Industrial Effluent
The color of the effluent was dark-brown with unpleasant odor. The pH of the effluent was neutral (7.32) and the electrical conductivity was 1720 micro mho/cm. Similarly, the effluent contained 1220 mg/L total dissolved solids and it also had high concentration of Calcium, sodium, Fluoride, Iron, Magnesium, Potassium, Phosphate, Silica, Sulphate, Nitrate, Chloride and free ammonia. The effluent had a higher value of COD (80 mg/L) than the BOD (24 mg/L) (Tables 1 and 2).

Table 1: Physical characteristics of the painting industrial effluent

PARAMETERS	VALUES
Appearance	C & C
Odor	Unpleasant odour
Turbidity	9.8
Total solids mg/L	1232
Total suspended solids mg/L	12
Total dissolved solids mg/L	1220
Electrical conductivity (micro mho/cm)	1720

Table 2: Chemical characteristics of the painting industrial effluent

PARAMETERS	VALUES
pH	7.32
Alkalinity pH ($CaCO_3$) mg/L	0
Alkalinity total ($CaCO_3$) mg/L	324
Total Hardness ($CaCO_3$) mg/L	590
Calcium (Ca) mg/L	156
Magnesium (Mg) mg/L	48
Sodium (Na) mg/L	116
Potassium (K) mg/L	12
Iron (Fe) mg/L	0.26
Manganese (Mn) mg/L	Nil
Free Ammonia (NH_2) mg/L	1.12
Nitrite (NO_2) mg/L	0.42
Nitrate (NO_3) mg/L	6
Chloride mg/L	79
Fluoride (F) mg/L	0.61
Sulphate (SO_4) mg/L	299
Phosphate (PO_4) mg/L	0.43
Tidy's Test (O) mg/L	7.2
Silica (SiO_2) mg/L	25.44
COD mg/L	80
BOD mg/L	24
Oil and Grease mg/L	0.0032
Total Nitrogen mg/L	2.24
Copper (Cu) mg/L	0.00214
Zinc (Zn) mg/L	0.328
Chromium (Cr) mg/L	0.0116

Effect of effluent, vermicompost and cow dung on growth parameters of *S. melongena* L.
Eggplant, *Solanum melongena* L., an angiospermic family member of Solanaceae, is a common and popular vegetable crop grown in the subtropics and tropics, even in pollutant contaminated regions. The growth parameters of *S. melongena* L. after ten days treatment with industrial effluent, vermicompost and cow dung compost manure were evaluated. Table 3 shows the effect of painting industrial effluent on the growth parameters of *S. melongena* L. It was noted that the length of the root and shoot, fresh and dry weight of the plant was considerably decreased with increase in concentration of the effluent and brought out decrease in the fresh weight of the plant (Table 3). It was observed that about 30% of reduction at 60% concentration was observed. With decrease in concentration of the effluent, there was a decrease in the dry weight of the plant were observed (Table 3). There was about 80% of reduction in the dry weight of *S. melongena* L.

A reduction in biomass accumulation observed in the various concentrations may be due to the toxic nature of the effluent. Krupa *et al.* **[4]** reported that the retardation in the growth of the plant was due to excess quantities of micronutrients and other toxic chemicals. Table 4 shows the effect of painting industrial effluent and vermicompost on the growth parameters of *Solanum melongena* L. There was not much difference with 40% effluent and vermicompost where the length of the root and shoot, fresh and dry weight, biomass and leaf area of the plant was considerably decreased with increase in concentration of the effluent with vermicompost. There was a gradual increase in all the parameters except the leaf area with increase in effuluent concentration with vermicompost (Table 4). There was no much reduction of total length at 20% concentration after ten days treatment with painting industry effluent. At 80% concentration, there was about 50% reduction in the total length (Table 4). Application of vermicompost in 80% reduction showed positive effect on the total length (80%) and cow dung 90% (Table 4 and 5). Cow dung compost manure showed better ameliorating effect than the vermicompost at high concentration of the effluent (Table 5). Drastic decrease in leaf area was found as the concentration of the effluent increased.

This was also similar in the case of effluent and cow dung where there was a considerable increase in the physiological parameters of the plant treated with 60% effluent with cow dung (Table 5). Organic manures like vermicompost and cow dung not only act as a source of nutrients and organic matter, but also increase size, biodiversity and activity of the microbial population in the soil, influence structure, nutrients turnover and many other related physical, chemical and biochemical parameters of the plants evident from the findings of Albiach *et al*. **[9]**.

Table 3: Effect of painting industrial effluent on the growth parameters of *Solanum melongena* L.

WATER SAMPLE	TOTAL LENGTH (cm)	ROOT LENGTH (cm)	SHOOT LENGTH (cm)	TOTAL FRESH WEIGHT (mg)	TOTAL DRY WEIGHT (mg)	LEAF AREA (cm)
CONTROL	22.41 ± 1.002	5.81 ± 2.59	16.6 ± 7.42	0.41 ± 1.597	0.35 ± 0.15	12.68 ± 8.96
20% EFFLUENT	15.97 ± 7.14	3.23 ± 1.44	12.73 ± 5.69	0.20 ± 0.089	0.16 ± 0.07	4.96 ± 2.86
40% EFFLUENT	15.47 ± 6.918	2.57 ± 1.149	12.9 ± 5.769	0.18 ± 0.08	0.14 ± 0.626	7.39 ± 5.22
60% EFFLUENT	13.97 ± 6.24	4.23 ± 1.89	9.73 ± 4.35	0.16 ± 0.071	0.11 ± 0.0491	5.42 ± 3.83
80% EFFLUENT	13.24 ± 5.92	3.1 ± 1.386	10.14 ± 4.53	0.12 ± 0.053	0.09 ± 0.04	5.43 ± 3.84

 # Value in parenthesis indicate percent activity
 # The value represents mean of 5 samples with their standard error (±)

Table 4: Effect of painting industrial effluent and vermicompost on the growth parameters of *Solanum melongena* L.

WATER SAMPLE	TOTAL LENGTH (cm)	ROOT LENGTH (cm)	SHOOT LENGTH (cm)	TOTAL FRESH WEIGHT (mg)	TOTAL DRY WEIGHT (mg)	LEAF AREA (cm)
CONTROL	22.41 ± 1.002	5.81 ± 2.59	16.6 ± 7.42	0.41 ± 1.597	0.35 ± 0.15	12.68 ± 8.96
20% EFFLUENT + VERMICOMPOST	17.3 ± 7.736	3.5 ± 1.565	13.8 ± 6.17	0.28 ± 0.125	0.17 ± 0.076	6.56 ± 3.787
40% EFFLUENT + VERMICOMPOST	15.6 ± 6.967	2.5 ± 1.118	13.1 ± 5.858	0.23 ± 0.1028	0.14 ± 0.0626	10.29 ± 7.27
60% EFFLUENT + VERMICOMPOST	16.7 ± 7.468	3.3 ± 1.475	13.4 ±5.99	0.19 ± 0.0849	0.13 ± 0.058	6.415 ± 4.53
80% EFFLUENT + VERMICOMPOST	16.5 ± 7.379	3.1 ± 1.386	13.3 ± 5.947	0.19 ± 0.0849	0.12 ± 0.0536	7.935 ± 5.61

Table 5: Effect of painting industrial effluent and cow dung compost manure on the growth parameters of *Solanum melongena* L

WATER SAMPLE	TOTAL LENGTH (cm)	ROOT LENGTH (cm)	SHOOT LENGTH (cm)	TOTAL FRESH WEIGHT (mg)	TOTAL DRY WEIGHT (mg)	LEAF AREA (cm)
CONTROL	22.41 ± 1.002	5.81 ± 2.59	16.6 ± 7.42	0.41 ± 1.597	0.35 ± 0.15	12.68 ± 8.96
20% EFFLUENT + COWDUNG COMPOST	18.83 ± 8.42	3.43 ± 1.533	15.4 ± 6.887	0.27 ± 0.1207	0.17 ± 0.076	8.07 ± 4.658
40% EFFLUENT + COWDUNG COMPOST	17.63 ± 7.88	2.5 ± 1.118	15.13 ± 6.766	0.27 ±0.1207	0.16 ± 0.0715	8.31 ± 5.86
60% EFFLUENT + COWDUNG COMPOST	20.0 ± 8.94	3.16 ± 1.413	16.8 ± 7.513	0.23 ± 0.1028	0.14 ± 0.0626	9.415 ± 6.67
80% EFFLUENT + COWDUNG COMPOST	17.1 ± 7.647	2.73 ± 1.22	14.36± 6.42	0.23 ± 0.1028	0.16 ± 0.071	9.67 ± 6.834

The inhibition of biomass accumulation is directly related to photosynthetic process, which in turn, depends upon the pigment content. The maximum reduction of chlorophyll content was reported in the treatment of black gram with 100% effluent from rubber factory**.** Comparing to the effect of effluent at high concentration, the cow dung manure at the vermicompost showed highly positive results (about 90% increase in leaf area) (Table 3, 4 and 5).

Effect of effluent, vermicompost and cow dung on pigment content of *S. melongena* L.

The contents of pigments in the leaves of plants are important to evaluate the photosynthetic apparatus of plants. Paint effluent affected the synthesis of pigments viz., chlorophyll and carotenoids of *S. melongena L* (Tables 6–8).

There was no change in the chlorophyll content on 80% effluent with vermicompost when compared to the control, whereas reduction in the carotenoids content was noted in 80% effluent with vermicompost. Our results are in consonance with the findings of Nagajyothi *et al*. **[13]** WHO reported that the increased chlorophyll content at lower concentration may be due to the favorable elements present in the effluent on the pigment system. Iron, magnesium, potassium, zinc and copper are essential for the synthesis of chlorophyll was proposed by Swaminathan and Vaidheeswaran **[14]**.

The increase in the chlorophyll, carotenoids content of plants at lower concentration of the effluent might be due to the favourable effect of nitrogen and other inorganic elements which are present in their optimum quantities. 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 Subramani *et al.* **[15]**. Presence of magnesium and potassium in their optimum quantities in the lower concentration of the effluent which are required for biosynthesis of pigment. In the chlorophyll estimation, chlorophyll a, b, total chlorophyll and carotenoids content of the plant significantly affected by the effluent. Zaller **[2]** was noted that the inhibition of biomass accumulation is directly related to photosynthetic process, which in turn, depends upon the pigment content. The maximum reduction of chlorophyll and carotenoid content was reported in the treatment of black gram with 100% effluent from rubber factory.

Table 6: Effect of painting industry effluent on the pigment content of *Solanum melongena* L

SAMPLES	CHLOROPHYLL *a*	CHLOROPHYLL *b*	TOTAL CHLOROPHYLL	CAROTENOIDS
CONTROL	0.40 ± 0.1804	4.41 ± 1.9722	3.75 ± 0.0864	0.0053 ± 0.0062
20% EFFLUENT	0.03 ± 0.013	1.29 ± 0.0578	1.07 ± 0.478	0.074 ± 0.033
40% EFFLUENT	0.09 ± 0.042	1.06 ± 0.474	0.84 ± 0.378	0.031 ± 0.0089
60% EFFLUENT	0.57 ± 0.25	0.51 ± 0.229	0.24 ± 0.1115	0.045 ± 0.0187
80% EFFLUENT	0.66 ± 0.24	0.47 ± 0.214	0.19 ± 0.086	0.037 ± 0.0232

Table 7: Effect of painting industry effluent and vermicompost on the pigment content of *Solanum melongena* L.

SAMPLES	CHLOROPHYLL*a*	CHLOROPHYLL*b*	TOTAL CHLOROPHYLL	CAROTENOIDS
CONTROL	0.40 ± 0.1804	4.41 ± 1.9722	3.75 ± 0.0864	0.0053 ± 0.0062
20% EFFLUENT + VERMICOMPOST	0.36 ± 0.1612	0.23 ± 0.1071	0.086 ± 0.0387	0.0098 ± 0.076
40% EFFLUENT + VERMICOMPOST	0.44 ± 0.201	0.20 ± 0.0924	0.03 ± 0.0136	0.0046 ± 0.0049
60% EFFLUENT + VERMICOMPOST	0.002 ± 0.0089	0.086 ± 0.0388	0.072 ± 0.0325	0.0014 ± 0.0004
80% EFFLUENT + VERMICOMPOST	0.451 ± 0.2016	0.293 ± 0.1313	0.103 ± 0.0462	0.023 ± 0.0143

Table 8: Effect of painting industry effluent and cowdung compost on the pigment content of *Solanum melongena* L

SAMPLES	CHLOROPHYLL *a*	CHLOROPHYLL *b*	TOTAL CHLOROPHYLL	CAROTENOIDS
CONTROL	0.40 ± 0.1804	4.41 ± 1.9722	3.75 ± 0.0864	0.0053 ± 0.0062
20% EFFLUENT + COWDUNG COMPOST	0.6298 ± 0.0093	0.2173 ± 0.0241	0.008 ± 0.0245	0.047 ± 0.0245
40% EFFLUENT + COWDUNG COMPOST	0.3914 ± 0.0067	0.1775 ± 0.0068	0.0303 ± 0.0290	0.059 ± 0.029
60% EFFLUENT + COWDUNG COMPOST	0.7232 ± 0.0169	0.566 ± 0.029	0.2463 ± 0.0308	0.052 ± 0.0975
80% EFFLUENT + COWDUNG COMPOST	0.7328 ± 0.01118	0.2776 ± 0.02817	0.0026 ± 0.0228	0.042 ± 0.0228

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