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Influence of fertiliser industry effluent on growth and biochemical composition of *Catharanthus roseus* (Madagascar periwinkle)

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ABSTRACT

The present study is an investigation into the effect of fertilizer industry effluent on plant growth and biochemical constituents of *Catharanthus roseus* (Madagaskar periwinkle), studied in a pot culture experiment. The degree of damage caused by the effluents on physiological and biochemical properties of plants was investigated. In the pot culture experiment, plants were grown up to 25 days, in the soil irrigated with different concentrations of fertilizer industry effluent (viz, 0, 30%, 60%, and 90% v/v). Each pot contained 3kg of air dried soil. All pots were irrigated (500 ml) with respective concentration of effluents daily. The higher fertilizer industrial effluent concentrations (above 30%) were found to affect plant growth negatively, decreased chlorophyll and protein contents, and increased polyphenol contents in the plants, but diluted effluent (up to 30%) favoured the plant growth and biochemical contents. This suggests that effluent threatens their normal metabolisms after some optimum concentration. Otherwise low concentration of the effluents can be effectively used for irrigation of this plant. © 2012 Trade Science Inc. - INDIA

KEYWORDS

Fertilizer manufacturing industrial effluents;
Catharanthus roseus;
Pot culture;
Growth;
Biochemical contents.

INTRODUCTION

Fertiliser industry has an immense importance in a country like India, to increase agricultural productivity and boost production for feeding the huge population of the country. Growth of fertiliser industry, however, has caused serious environmental problems. The process involved in the production of fertilisers generates effluents and emissions which contribute to environmental degradation including green house effect, stratospheric ozone depletion, acid rain and acidification, eutrophication, soil degradation, technological hazards and chemical mists etc. Generally effluents from phosphate fertilizer industries are acidic in nature with pH ranging between 1 and 3.5, while effluents from nitrate fertiliser industries have alkalaine pH ranging between 9 and 10.5[1] which at most of the times are discharged into nearby water-bodies without appropriate treatment. In arid and semi arid regions of our country where there is shortage of water for irrigation, effluents offer an option to be used with water for irrigation of crops. This creates the risk of the effluent contamination for the crops; therefore it is necessary to assess the suitability of these effluents for crop irrigation.

There has been a long controversial debate on utilization of effluents emanating from industries for irrigation of crops. Unfortunately a lot of studies hinted at the negativity of the concept and indicated that industrial effluents have a suppressing effect on the growth and productivity of crops. A number of studies on the application of fertilizer effluent on plant growth and associated biochemical changes have been undertaken by various researchers[2-6]. In lower concentration enhanced growth and decreased dry matter production and photosynthetic pigments of corn and rice was observed[7]. Sarma and co workers[8] observed weeds to be susceptible while *C. bonplandianum* to be tolerant to some extent when irrigated with fertilizer industry effluent. The present study was attempted to investigate the effect of Fertiliser industry effluent on an ornamental plant *Catharanthus roseus*. Also known as Madagascar periwinkle, and belonging to Apocynceae is a tender, perennial herb or a subshrub, sprawling along the ground or standing erect up to a metre in height. It contains milky latex used for medical purposes extensively. Effects were monitored in the growth, chlorophyll content, polyphenol content and protein content in plants subjected to effluent irrigation for a stipulated period of 25 days. The objective is to assess the suitability of fertilizer industry effluent for crop irrigation.

MATERIALS AND METHODS

Physicochemical characterisation of effluent

Fertilizer industrial effluent samples were collected from the point of discharge during February to March 2011. The effluent samples were collected in plastic container and stored in freeze box for transport to the laboratory. Later the effluents were analysed for its various physico-chemical parameters like colour, odor, suspended solid, pH, DO, BOD, COD, TDS, TS, chloride, alkalinity, hardness, sulphate, phosphate and nitrate according to APHA[9] methods.

Experimental design

The impact of effluent on the growth and biochemical characteristics of the selected plant, *Catharanthus* roseus was first investigated using soil pots (15 cm height 15 cm width). About 3kg of air dried soil was taken into separate pots. Three different concentrations (viz., 30%, 60% and 90%) of fertilizer industry effluent were prepared and poured into each pot. The control was also maintained and irrigated with tap water. The inner surfaces of pots were lined with a polythene sheet. All pots were irrigated with 500ml of respective concentration of test solutions daily. Each treatment including the control was replicated five times. Young plantlets of approximately equal length, size, and morphology of both the species were taken. All the plantlets were grown into same soil and same conditions. At every 5 days of interval 1 plant from each dilution were analysed for its growth and biochemical parameters. In this way the study was carried out for 25 days.

Growth and biochemical changes monitoring in plants

The plant samples were collected at every 5 days interval after sowing and analysed for growth parameters such as length of root and shoot.

Biochemical parameters were estimated according to standard protocols. The method of Lowry[10] was used for protein determination. Chlorophyll was estimated spectrophotometrically according to the method of Arnon[11]. The estimation of total phenolic compounds was done according to the method of Malik and Singh[12].

Statistical analysis

Data points in the TABLES and Figures represent the means, with all deviation bars shown (± standard deviations of mean). Both the mean and standard deviation were performed where appropriate using the statistical package on Microsoft_ Excel Version 2003.

RESULTS AND DISCUSSION

The physicochemical characteristics from the final discharge point of Fertiliser industry effluent was as follows: The effluent was light brown in colour and slightly turbid in appearance, pH ranging from 7.58 to 8.4 with absence of any odour. TDS was considerably high with values ranging from 856 to 2868 mg/L. Dissolved solid

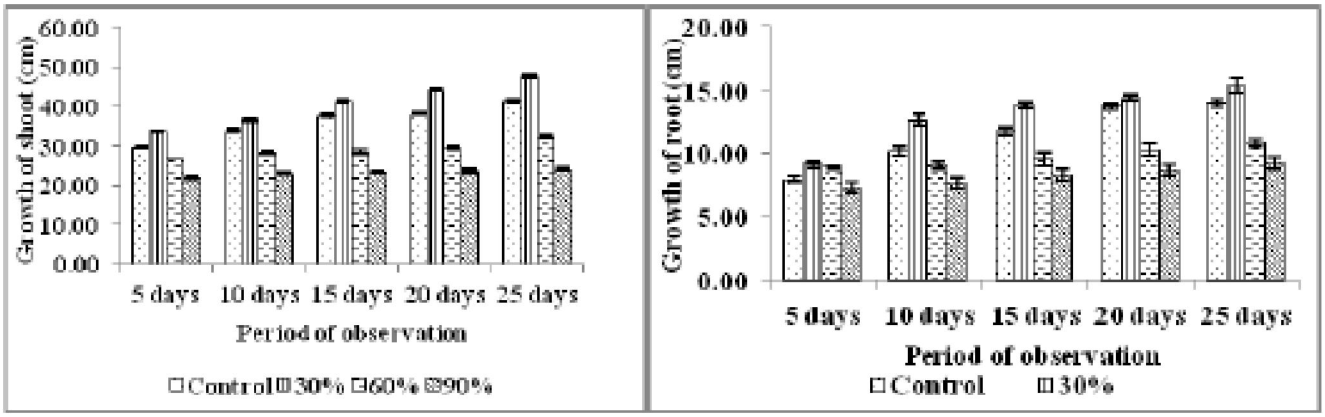

Figure 1 : Effect of fertilizer effluent on growth of shoot and root of *Catharanthus roseus*. (Mean ± SD)

was found to be varying between 335 to 405 mg/L. Suspended solid ranged between 78 to 136 mg/L. Phosphate ranged between 26 to 68 mg/L, nitrate (4.8 to 12.8 mg/L), chloride (18.18 to 36.5 mg/L and sulphate 55 to 72 mg/L. Dissolved oxygen variation was between 1.8 to 4.4 mg/L. BOD and COD values were found to be 32.58 to 38.44 mg/L and 268 to 322 mg/L.

Growth

Root and shoot length of the plants differed with different concentrations of fertilizer manufacturing effluents in the soil (Figure 1). At lower effluent concentration (30%) it was observed that the shoot and root length was higher than the plants kept as control, which suggests that lower concentration of the effluent was containing growth stimulating nutrients and is favourable for growth of the plants, while for higher concentrations (60% and 90%), stunted growth of the plants in terms of both root and shoot was evident indicating development of some toxic effects on the plant physiology and biochemistry. This trend is similar to previous report of Kaushik[13], who reported a clear toxicity of sugar factory effluent on the growth, photosynthetic pigments and nutrient uptake in wheat seedlings in aqueous versus soil medium. After 25 days the root length in control pots wer found to be 14.03 ±0.31 cm, while in 30% effluent dosed pot it was 15.33 ± 0.61 cm indicating a 9.26% increased growth, but in 60% and 90% effluent there was a reduced growth of 23.02% and 33.71%. This indicates clear toxicity, which corroborates with earlier studies like the reports of effect of dairy effluent on paddy plants[14] and effect of sugar mill effluent on *Raphanus sativus*. L[15].

Similarly for shoot length also similar trend was observed. At 25th day, the shoot length of the periwinkle plants were average 41.37 ± 0.40 cm, while at 30% effluent treatment the length of the plants increased to 47.67 ± 0.47 cm indicating a 15.22% enhanced growth. But at the same time higher effluent concentrations (60% and 90%) lead to a decreased growth of 21.60 and 41.74% respectively.

The probable causes for this stunted growth due to high effluent concentration is the constituents of the fertilizer industry effluent consisting of excess amount of chloride, sulphate, nitrate and phosphate.

All chlorophylls serve as the primary means which plants use to intercept light in order to fuel photosynthesis and indicate the state of growth and development. In our study it was observed that at 30% effluent irrigation the chlorophyll content increased steadily and was above all the other treatments. Chlorphyll value in control plant increased from 0.88 mg/g in five days treatment to 1.30

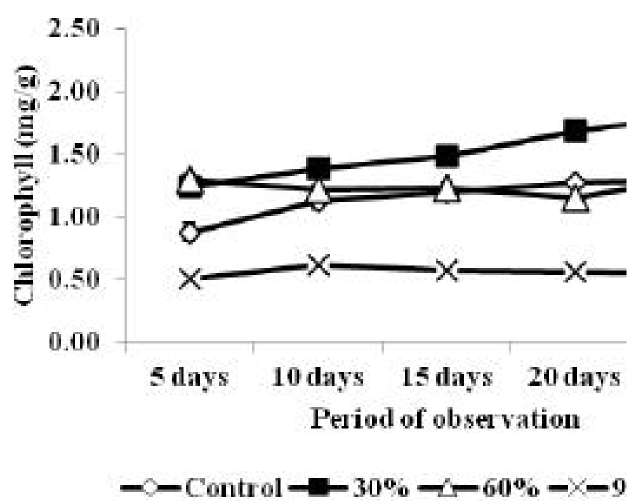

Figure 2 : Effect of fertilizer effluent on chlorophyll content of *Catharanthus roseus*. (Mean ± SD)

± 0.03 mg/g in 25 days, whereas in 30% effluent irrigated plant, it increased from 1.24± 0.05 mg/g in five days to 1.82± 0.10 mg/g in 25 days (a 40 percent increase). Even in 60% treatment the chlorophyll content was nearly similar but in 90% effluent treatment, it decreased to 0.55± 0.06 mg/g (a 57.69 percentage decrease). This suggests that the chlorophyll pigment of the plants increases with low effluent irrigation, but at very high concentration, it decreases responsively (Figure 2).

Increased chlorophyll content at lower concentration may be due to the favorable elements present in the effluent on the pigment system[16]. Iron, magnesium, potassium, zinc and copper are essential for the synthesis of chlorophyll[17]. In addition to this nitrate and phosphate, present in adequate amount in the effluent also leads to synthesis of enhanced chlorophyll[18]. However at higher concentration, these favourable constituents cross their optimum limits and become toxic. Here chlorophyllase enzyme plays a vital role in chlorophyll metabolism as well as homeostasis for the plant at higher concentration[15,16,19,20]. Apart from this the inhibition of chlorophyll synthesis may also be due to Cu-induced inhibition of ALAdehydratase[21]. Izawa[22] suggested that the inhibition of chlorophyll may be due to the induced inhibition of Electron Transport System in PS-I.

Protein content seemed to be enhanced upto 60% effluent treatment of the *C. roseus* plants in the initial phase up to 15 days, but after that protein content in 30% effluent continued to increase the maximum, while it decreased in the higher concentrations (Figure 3).

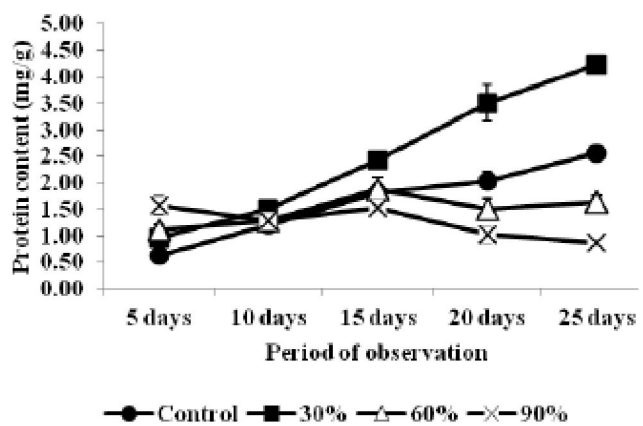

Figure 3 : Effect of fertilizer effluent on protein content of *Catharanthus roseus.* (Mean ± SD)

In 90% the protein content was found to be highest after 5 days but then it decreased continuously till 25th day. In 30% effluent irrigated plants the total protein content was 65.63% higher than the control plants. However it was found to be 35.94% and 66.01% lower in 60% and 90% respectively after 25 days. The enhancement of protein content of the plants might be due to increased rate of amino acid synthesis which may be attributed to the the higher rates of both RNA-ase and transaminase activity[23]. The significant increase in the protein content of plant can be attributed to the optimum quantity of potassium and nitrate in the lower concentration of the effluent as reported by Kadioglu and Algur[24] in pea plants.

Phenols are oxidised by peroxidase (POD) and primarily by polyphenol oxidase (PPO) in plants in response to different types of stress, both biotic and abiotic, this latter enzyme catalysing the oxidation of the *o*-diphenols to *o*-diquinones, as well as hydroxylation of monophenols[25]. In our study phenol content in the plants got enhanced irrigated with effluent. The range of phenol in control pant was 0.09± 0.01 mg/g to 0.13± 0.01 mg/g, while it increased from 0.13± 0.02 mg/g within five days growth to 0.43± 0.04 mg/g and 0.77± 0.04 mg/g in 60% effluent (Figure 4). Interestingly in 90% effluent treatment the phenol content shoot upto 0.91± 0.05 mg/g within 10 days but then it had a gradual decrease to 0.43± 0.07 mg/g after 25 days.

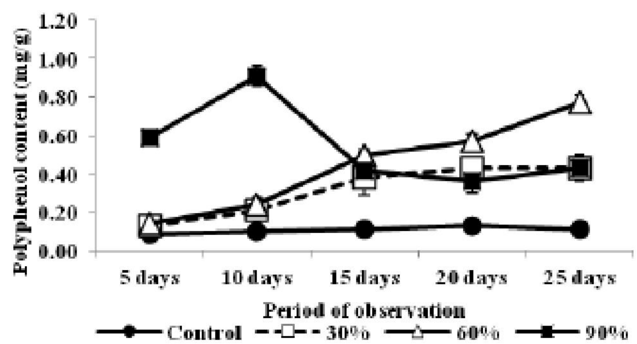

Figure 4 : Effect of fertilizer effluent on polyphenol content of *Catharanthus roseus.* (Mean ± SD)

Overall phenolics content in the plants were enhanced in all the effluent treatments. phenolic compounds are accumulated perhaps as results of an acclimation mechanism to overcome stress in *Catharanthus roseus* due to fertilizer effluent irrigation.

CONCLUSION

The overall observation suggests that the fertilizer industry effluent contained relatively high concentrations of alkalinity, nitrate, phosphate, BOD, COD and sulphate values. These concentrations seemed to detrimentally affect the growth and biochemical parameters of the plant *Catharanthus roseus*. Both root and shoot length was significantly affected by the effluent treatment. 30% effluent treatment enhanved he growth considerably, while higher concentrations suppressed growth. Chlorophyll and protein concentrations decreased after 25 days observation in higher concentration effluent irrigated plants. Phenolics showed a trend to increase in all the effluent irrigated plants compared to the control, though in 90% concentration phenolics content in the initial phase increased markedly, but later decreased. So finally it can be concluded that fertilizer effluent in low concentration is beneficial for growth and proximate composition of plants, though at high concentration it becomes toxic. This concept will widen the application of fertilizer effluent for irrigation commercially if judicious application is done.

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REFERENCES

[1] G.F.Durrani, A.Zahoor, M.K.Baloch; J.Chem.Soc.Pak., **29(4)**, 328-331 **(2007)**.

[2] S.P.Adhikary, A.K.Bastia, P.K.Tripathy; Bull. Environ.Contam.Toxicol., **49(1)**, 144-173 **(1992)**.

[3] S.K.Agarwal, G.Hemlata; Acta.Ecol., **14(1)**, 53-60 **(1992)**.

[4] M.Goswami; Proc.Acad.Environ.Biol., **2(1)**, 11-15 **(1993)**.

[5] S.N.Singh; J.Ecobiol., **6**, 27-32 **(1994)**.

[6] P.P.Singh, M.Mall, J.Singh; Journal of Env.Biol., **27(1)**, 153-156 **(2006)**.

[7] K.K.Singh, L.C.Mishra; Water Air and Soil Poll., **33(4-4)**, 309-320 **(1987)**.

[8] H.Sarma, A.Sarma, C.M.Sarma; J.Ecol.Nat.Env., **1(7)**, 173-177 **(2009)**.

[9] APHA Standard Methods for the Examination of Water and Waste Water, 20th Edition. American Public Health Association, Washington DC, **(1998)**.

[10] O.H.Lowry, N.J.Rosebrough, A.L.Farr, R.J.Randall; J.Biol.Chem., **193**, 265-275 **(1951)**.

[11] D.I.Arnon; Plant Physiol., **24**, 1-15 **(1949)**.

[12] C.P.Malik, M.B.Singh; Plant Enzymology and Histoenzymology,. Kalyani Publisher; New Delhi, **(1980)**.

[13] Kaushik, B.R.Kadyan, C.P.Kaushik; Water Air Soil Poll., **87**, 39-46 **(2004)**.

[14] S.Dhanam; Bot.Res.Int., **2(2)**, 61-63 **(2009)**.

[15] M.Vijayaragavan, C.Prabhahar, J.Sureshkumar, A.Natarajan, S.Vijayarengan, S.Sharavanan; Curr. Bot., **2(7)**, 09-13 **(2011)**.

[16] P.C.Nagayjoti, N.Dinakar, N.Prasad, C.Suresh, T.Damodharan; Applied Sciences Research, **4**, 110-121 **(2008)**.

[17] K.Swaminathan, P.Vaidheeswaran; J.Env.Biol., **12**, 353-358 **(1991)**.

[18] Subramani, P.Sundaramoorthi, S.Saravanan, M.Selvaraju, A.S.Lakshmanachary; J.Indust.Poll. Cont., **15(2)**, 281-286 **(1999)**.

[19] P.Gupta, S.K.Dwivedi, C.Sharma, A.Srivastave, S.Verma, PlantArchives, **4(2)**, 413-417 **(2004)**.

[20] M.D.Saravanamoorthy, B.D.Ranjitha Kumari; Biochem, Cell Archs., **5(1)**, 113-117 **(2005)**.

[21] L.Scarponi, P.Perucci; Pi. and Sci., **79**, 69-75 **(1984)**.

[22] S.Izawa; Photosynthesis. A.Trebest, H.Avron, (Eds); Springer Verlag, Berlin, 256-286 **(1977)**.

[23] V.K.Singh; J.of Adv.in Plant Sci., **4**, 153-158 **(1991)**.

[24] Kadioglu, O.F.Algur; Environ.Poll., **67**, 223-232 **(1990)**.

[25] R.M.Rivero, J.M.Ruiz, P.C.Garcý´a, L.R.Lo´pez-Lefebre, E.Sa´nchez, L.Romero; PlantSci., **160**, 315-321 **(2001)**.