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Research Article

Impact of domestic sewage effluent on the growth and yield of *Vigna radiata* (L.) Wilczek

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Abstract

Sewage is a complex mixture of chemicals, with many distinctive chemical characteristics. Sewage also contains the nutrients nitrogen and phosphorus. The present study has been undertaken to assess the impact of domestic sewage effluent on morphological, biochemical and physiological characteristics of *Vigna radiata* (L.) Wilczek. The effluent was analyzed for various physicochemical parameters. Domestic sewage effluent is characterized by its pale black colour with unpleasant odour, high BOD, COD, TDS, EC and total hardness. Pot culture experiments were conducted with *Vigna radiata* plants at different concentrations (20%, 40%, 60%, 80%, 100%) of domestic sewage effluent along with control using ground water. The morphological parameters such as shoot length, root length, leaf area, fresh weight, dry weight, biochemical parameters such as carbohydrate, protein, aminoacid content and physiological parameters such as chlorophyll a, chlorophyll b, total chlorophyll and carotenoid content were analysed at 15, 25, 35 days after sowing. The yield parameters of green gram plants were recorded at the time of harvest. All morphological, biochemical, physiological parameters were found to increase at 20% effluent concentration and it decreased from 60% concentration onwards. Yield was maximum in 60% effluent treated plants. At 60% effluent concentration detrimental effect on the plant growth was observed when compared to control. The results showed that the sewage effluent is toxic to plant growth at higher concentration, thus it can be used for irrigation after proper dilution.

INTRODUCTION

Industrial revolution is a great boon to mankind but there is a wide range of environmental impacts created by industries (Behera and Reddy, 2002). Industrial pollution is one of the problems presently facing in India and several efforts are being vigorously persued to control it (Kathirvel and Kumudha, 2011). Over ¾th of fresh water drawn by the domestic and industrial effluents inevitably end up in surface water bodies or in the ground water (Buechler and Mekala, 2005). Thus most of our water resources are gradually becoming polluted by addition of huge amounts of sewage and industrial effluents. The discharge of industrial and sewage effluents with varying amounts of pollutants hence altered the water quality (Vijayaragavan *et al.*, 2011).

Untreated sewage water and the industrial effluents are also discharged directly into water channels or canals and the polluted water is used for growing crops particularly vegetables and fodder in the vicinity of big cities (Khan *et al.*, 2003). One of the effective mechanisms to minimize the load of waste water is its utilization for irrigation purposes.

Sewage effluent is considered to be a source of organic matter and plant nutrients it also contain considerable amounts of soluble salts (O'Riordan, 1994). Nowadays treated effluent is considered as a potential water resource because it contains considerable amount of nutrients, which may prove beneficial for plant growth (Sahai *et al.*, 1985;Mishra and Behera, 1991). Since there has been an increased interest in alternative and innovative technologies which will prone to be of low cost, low maintenance and energy efficient (Abirami *et al.*, 2005). Effects of various industrial effluents on seed germination, growth and yield of crop plant have captivated the attention of many workers (Ozoh and Oladimeji, 1984; Rahman *et al*., 2002; Street *et al*., 2007). So various researchers have carried out studies concerning the effects of different concentration of effluents on different crop species (Malaviya and Sharma, 2011; Medhi *et al.*, 2011; Kaushik *et al.*, 2005). The present investigation was conducted to evaluate the impact of different concentration domestic sewage effluent on the growth of *Vigna radiata* and to assess the sewage effluent on morphological, biochemical and physiological content of the plants.

MATERIALS AND METHODS

Collection of effluent and seed material: Domestic sewage effluent was collected from the residential area near Nattalam village of Kanyakumari district. The effluent was analyzed for its various physicochemical parameters. Seeds of *Vigna radiata* were purchased from Agricultural Extension Centre, Marthandam. Seeds free from visible defects and uniform size were surface sterilized with 1% sodium hypochlorite and sown in circular earthern pots (25cm height and 28 cm diameter) filled with a mixture of garden soil, sand mixture and farmyard manure in the ratio of 1:2:1. Selected physicochemical parameters such as temperature, pH, conductivity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen demand (COD), in the effluent was analyzed according to (APHA,1995).

Application of sewage Effluent

Different concentration of effluents was applied as per the method followed by Medhi *et al*. (2011). The different treatments such as control (tap water), 20%, 40%, 60%, 80% and 100% concentration of the effluents irrigated in 6 different seeds containing pots. The pots were irrigated with different concentration of effluents. Three plants were collected from each treatment and analyzed. By irrigating the effluent with different concentration to study the morphological, biochemical and physiological parameters. The morphological parameters such as shoot length, root length, leaf area, fresh weight, dry weight were measured at 15, 25, 35 Days after sowing.

Biochemical estimations

Estimation of carbohydrate content was done by the method of (Sadasivum and Manikam, 1992, Estimation of protein content done by the method of (Lowry *et al*., 1951) and estimation of Aminoacid content done by the method of (Moore and Stein, 1948).

Physiological estimations

Estimation of Chlorophyll a content, Chlorophyll b content, Total Chlorophyll, carotenoid content was done by the method of (Arnon, 1949).

Yield studies

Plants were collected at the time of harvest for the observation of yield parameters such as number of flowers, number of pods per plant, number of seeds per pod, length of pod, fresh and dry weight of pod.

RESULTS AND DISCUSSION

Effluent characteristics

The colour of the domestic sewage effluent was pale black with unpleasant odour. The pH 5 which was acidic in nature. Total dissolved solids of effluent was found to be 93.3 mg/L and Electrical conductivity was noted as 175 dsm^{-1} which was above the permissible limits. BOD was found to be 125 mg/L. COD was found to be 440 mg/L which exceed the permissible limit. The domestic sewage effluent showed 5.4 m.e/L of bicarbonate content Total hardness of sewage effluent the recorded value was 1240 mg/L, Which exceed the permissible limits. The domestic sewage effluent showed higher amount of suspended solids, Biological oxygen demand and Chemical oxygen demand. In addition, it contains considerable amount of bicarbonate content. This specifies that amount of organic matter present in effluent is towards higher side of its limits which may create stress upon biological system if released in water body as it is. The same was reported by many workers (Maygaonkar *et al*., 2012; Vijayaragavan *et al.*, 2011;Sankpal, 2012)

Morphological study

The plants showed a stimulatory effect in lower concentrations of the effluent treated plants upto 20% concentration. Control plants showed a lesser shoot length than treated plants. The domestic sewage effluent treated plants showed a maximum shoot length of 16.66 ± 0.94 cm, 25 ± 1.41 cm and 35.33 ± 0.47 cm on the 15th, 25th and 35th day after planting at 20% effluent treatment. The minimum shoot length noticed in 100% concentration in the domestic sewage treated plants that were found to be 11.33 ± 0.47 cm, 14 ± 0.81 cm, and 17 ± 1.41 cm on the 15th, 25th and 35th day after planting. The root length in the domestic sewage treated plants showed a maximum length of root length of 4.5 ± 0.40 cm, 8.33 ± 2.62 cm and 14.66 ± 0.94 cm on the 15th, 25th and 35th day after planting. . The domestic sewage effluent treated plants showed maximum number of leaves in 20% concentration on the 15th 25th and 35th day after planting. The values noted was 8 ± 0.47,11 ± 0.47, 18 ± 1.41 respectively. Domestic sewage effluent treated plants showed a maximum leaf area of 15.69 ± 0.96,16.27 ± 0.82 and 32.30 ± 0.88 cm in 20% concentration. On the all t three noted days domestic sewage effluent treated plants showed high number of lateral roots 15 ± 0.81, 21.33 ± 0.94 and 29 ± 0.94 respectively. Domestic sewage effluent treated plants showed a plant height of 21.16 ± 1.34 cm, 33.33 ± 4.03 cm and 49.99 ± 1.41 cm on the 15th , 25th and 35th day after planting in 20% concentration. At higher concentration, low growth was observed in the effluent treated plants. The higher shoot and root lengths were recorded at 20% effluent concentration. The root and shoot length were adversely affected by higher concentration of effluent treatment. The same findings were reported earlier due to treatment by (Kumar and Bhargava, 1998) and Hariom *et al*. (1994). The reduction in shoot and root growth at higher concentration of effluent may be due to the fact that germinated seeds under higher concentration would get less amount of oxygen which might have restricted the energy supply and retarded the growth and development (Kumar, 2000). Leaf area was also seemed to be reduced in higher concentration of the effluents. It may be due to the reduced cell size and decrease intercellular spaces were largely responsible for reduction in leaf area due to effluent toxicity (Dutta and Boissya, 1999). Overall the height of the plants were reduced at higher concentration Due to continuous irrigation with the effluents the soil becomes harder and closed the pores of the soil are closed causing less aeration and retarding the growth of the plant (Singh *et al*., 2005).

Table 1 : Effect of domestic sewage effluent on the morphological parameters of *Vigna radiata* (L.) Wilczek noted on the 35th day after planting

Various Concentration	*Shoot length	*Root length	*No. of leaves	* Leaf area	*No.of lateral roots	*Height of plant
Control	22.66 ±0.47	12 ± 0	11 ± 0.81	13.37±0.44	21.33 ± 1.24	34.6 ± 0.47
20%	35.33 ±0.47	14.66 ±0.94	18 ± 1.41	32.30±0.88	29.33 ± 0.94	49.99 ± 1.41
40%	28.66 ±1.24	12.16±0.23	14.66±0.94	25.72±0.62	28.33 ± 0.47	40.82 ± 1.47
60%	25.33 ±0.47	7.83±0.62	12 ± 1.41	22.83±0.91	25.33 ± 0.47	33.16 ± 1.09
80%	19.16±1.02	6.83 ± 0.62	10 ± 0.81	17.33±0.38	19.33 ± 0.47	24.99 ± 1.64
100%	17±1.41	5.16 ± 0.23	9 ± 1.41	9.91±0.71	18.33 ± 0.47	22.16 ± 1.64

* Replicates of three

Biochemical study

The carbohydrate content was comparatively higher than control in domestic sewage effluent treated plants. On the 15th day after planting, sewage effluent treated plants showed maximum in 40% concentration (0.45 ±0.004 mg/g.fr.wt). . On the 25th day after the maximum content noticed in domestic sewage effluent treated plants which was 0.35 ± 0.008 mg/g. fr.wt in 20% concentration. On the 35th day there was a sudden increase in the carbohydrate content in the domestic sewage effluent treated plants. The maximum value recorded in domestic sewage treated plants in 40% concentration which was 0.55 ± 0.008 mg/g. fr.wt.

Protein content

All the effluent treated plants showed high protein content than control. The domestic sewage effluent treated plants showed maximum protein content on the 15th day after planting. The maximum protein content noticed was 0.64 ± 0.000 mg/g. fr.wt in the 40% concentration on the 15th day after planting. The domestic sewage effluent treated plants also showed a maximum protein content of 0.48 ± 0.004 mg/g. fr.wt on the 25th day after planting in 60% concentration. On the 35th day after planting protein content of domestic effluent treated plants showed value of 0.85 ± 0.000 mg/g. fr.wt. On the 35th day after planting The domestic sewage effluent showed a higher protein content in domestic sewage effluent treated plants than control.

Amino acid content

The amino acid content was more in domestic sewage effluent treated plants. Amino acid content of 0.47 ± 0.004 mg/g. fr.wt was noted in 20% effluent treated plants. On 25th day maximum aminoacid content of 1.46 ± 0.094 mg/g. fr.wt noted in 80% effluent treated plants. The domestic sewage effluent treated plants showed a maximum amino acid content of 2.26 ± 0.047 mg/g. fr.wt on the 35th day in 60% concentration, At higher concentrations, the treated plants showed a higher amino acid content when compared to control. Plants when treated with different concentration of effluent showed a marked difference in the biochemical content than control. The lesser carbohydrate content at higher concentration was recorded. It implies the poor metabolism. The decrease in higher concentration may be due to the excessive nitrogen uptake caused imbalance between nitrogen uptake and assimilation and a large supply of nitrogen might eventually lead to depletion of carbohydrate reserve (Baskaran *et al.*, 2009). One of the major molecules severely affected by stress is protein (Giese, 1964). Hence, protein in leaf was analyzed. The result revealed that the reduction in protein content was very obvious with an increase in the concentration of sewage effluent. Lower concentration of the effluent treated plants showed high protein content. The increase in protein content of green gram at lower concentration of sugar mill effluent was observed by Baskaran *et al.* (2009). It might be due to adsorption of most of the necessary elements by plants (Neelam and Sahai, 1985). Further the recorded values decreased with the increase in the concentration of the effluent (above 80%). Several researchers contributed various reasons for the reduced amount of biochemical contents. The similar results showed the presence of high concentration of various cations and anions in the effluent and may be the due to the changes induced by the effluent stress (Behera *et al.*, 1980).

A reduction in soluble protein content eventually leads to increase in free amino acid content. Hence free amino acid content was analyzed. Amino acid content was generally more than protein content this may be due to higher protease enzyme activity The breakdown of protein into amino acids is also adversely affected due to effluent toxicity. Hence poor availability of nitrogen may be causative factor for reduction in protein content (Muthusamy and Jayabalan, 2001). Amino acid content decreased at higher concentration. The decreasing activity may be due to the inhibitory effect of the protease activity.

Table 2: Effect of domestic sewage effluent on the biochemical parameters of *Vigna radiata* (L.) Wilczek noted on the 35th day after planting

Various Concentration	*Carbohydrate	*Protein	*Amino acid
Control	0.35 ± 0.000	0.39 ± 0.000	0.40 ± 0.009
20%	0.46 ± 0.008	0.50 ± 0.006	1.21 ± 0.020
40%	0.55 ± 0.008	0.60 ± 0.004	1.45 ± 0.093
60%	0.36 ± 0.040	0.85 ± 0.000	2.26 ± 0.047
80%	0.34 ± 0.004	0.56 ± 0.004	1.36 ± 0.014
100%	0.33 ± 0.004	0.35 ± 0.004	1.2 ± 0.047

* Replicates of three

Physiological studies

Chlorophyll a content

The treatment of plants with domestic sewage effluent showed maximum chlorophyll a content in 40 % concentration. The chlorophyll a content when noticed on the 15th, 25th and 35th day that showed higher value of 1.081 ± 0.030, 1.493 ± 0.028, and 0.927 ± 0.0034 mg/g. fr.wt respectively. The chlorophyll a content was more on the 25th day after planting after that reduction was noticed.

On the 15th day domestic sewage effluent treated plants showed a better chlorophyll a content. Domestic sewage effluent plants showed a minimum chlorophyll a content of 0.073 ± 0.001, 0.354 ± 0.0015 mg/g. fr.wt respectively at 100% effluent concentration on all three noted days.

Chlorophyll b content

All the treated plants showed better chlorophyll b content. The domestic sewage effluent treated plants showed maximum chlorophyll content on the 25 th and 35th day after planting in 40% concentration. The recorded value was 1.149 ± 0.003 and 1.410 ± 0.004 mg/g. fr.wt . At higher concentration above 80% showed less amount of chlorophyll b content than control.

Total chlorophyll

Domestic sewage treated plants showed a maximum value on the 25th day after planting (2.541 ± 0.004 mg/g. fr.wt) in 40% concentration. The highest value recorded in 40 % concentration on the 15th , 25th and 35th day after planting were 2.216 ± 0.009, 2.541 ± 0.004 and 2.387 ± 0.003 mg/g. fr.wt respectively. Higher concentration showed low chlorophyll content. This showed inhibitory to synthesis of chlorophyll molecules (Khan *et al.*, 2011). The inhibition of chlorophyll synthesis probably results from the Cu-induced inhibition of ALA-dehydratase reported by Scarponi and Perucci (1984). The inhibition of chlorophyll may be due to the induced inhibition of Electron Transport System in PS-II (Izawa, 1977).

Carotenoid content

At lower concentration, both domestic sewage effluent treated plants showed higher carotenoid content than control whereas higher concentration of the effluent treated plants recorded lower carotenoid content than control. The domestic sewage effluent treated plants showed a maximum value in 60 % concentration when noticed on the 15th day and 25 th day which showed a maximum value of 1.486 ± 0.061 and 1.211 ± 0.002 mg/g. fr.wt. On the 35th day after planting 40 % of the effluent treated plants showed the value of 0.444 ± 0.031 mg/g. fr.wt. The reduction in carotenoid content on the 35th day than 25th day after planting was recorded in domestic sewage treated plants. Increase in carotenoid content in lower concentration of the effluent was recorded during the present study . The decrease in carotenoid content at higher concentration of textile effluent was also reported by (Garg and Kaushik, 2007). The increase in carotenoid content may be due to enhanced influence of nitrogen and other organic elements present in the effluent Subramani *et al.* (1999).

Table 3: Effect of sewage effluent physiological parameters of *Vigna radiata* (L.) Wilczek noted on the 35th day after planting

Various concentration	*Chlorophyll a	*Chlorophyll b	*Total Chlorophyll	*Carotenoid
Control	0.420± 0.001	0.581 ± 0.002	1.001 ± 0.124	0.112 ± 0.009
20%	0.500 ± 0.001	0.911 ± 0.039	1.411 ± 0.044	0.351 ± 0.036
40%	0.927 ± 0.003	1.410 ± 0.078	2.387 ± 0.003	0.444 ± 0.031
60%	0.581 ± 0.005	0.596 ± 0.003	1.177 ± 0.004	0.331 ± 0.021
80%	0.419 ± 0.003	0.301 ± 0.004	0.721 ± 0.003	0.114 ± 0.010
100%	0.404 ± 0.003	0.280 ± 0.003	0.682 ± 0.002	0.100 ± 0.006

* Replicates of three

Biomass content of the plants

The biomass of both treated and untreated control plants were observed and analyzed. The control plants showed much lower biomass content than treated plants noted during the study period. The domestic sewage effluent treated plants showed higher biomass at 20% concentration. High biomass was recorded in domestic sewage effluent treated plants which showed a value of 0.85 ± 0.004 gm, 1.50 ± 0.368, 2.66 ± 0.571 gm of fresh weight and dry weight of 0.40 ± 0.004 gm, 0.80 ± 0.094 gm, 1.60 ± 0.432 gm respectively noted at 15th, 25th, 35th days after planting

Table 4: Effect of domestic sewage effluent on the fresh and dry weight of *Vigna radiata* (L.) Wilczek

Various concentration	15th DAY		25th day		35th day	
	*Fresh weight	*Dry weight	*Fresh weight	*Dry weight	*Fresh weight	*Dry weight
Control	0.51 ± 0.008	0.35 ± 0.008	0.80 ± 0.008	0.40 ± 0.004	1.20 ± 0.081	0.96 ± 0.047
20%	0.85 ± 0.006	0.40 ± 0.004	1.50 ± 0.368	0.80 ± 0.094	2.66 ± 0.471	1.60 ± 0.432
40%	0.68 ± 0.004	0.34 ± 0.008	1.20 ± 0.047	0.60 ± 0.004	2.33 ± 0.235	1.28 ± 0.271
60%	0.53 ± 0.004	0.40 ± 0.023	1.00 ± 0.141	0.50 ± 0.271	2.16 ± 0.047	1.33 ± 0.235
80%	0.43 ± 0.004	0.34 ± 0.008	0.98 ± 0.094	0.43 ± 0.004	1.83 ± 0.235	1.05 ± 0.075
100%	0.09 ± 0.008	0.01 ± 0.004	0.80 ± 0.285	0.40 ± 0.444	1.60 ± 0.141	0.81 ± 0.259

* Replicates of three

Fig 1: Effect of different concentration of domestic sewage effluent on pods/ flowers

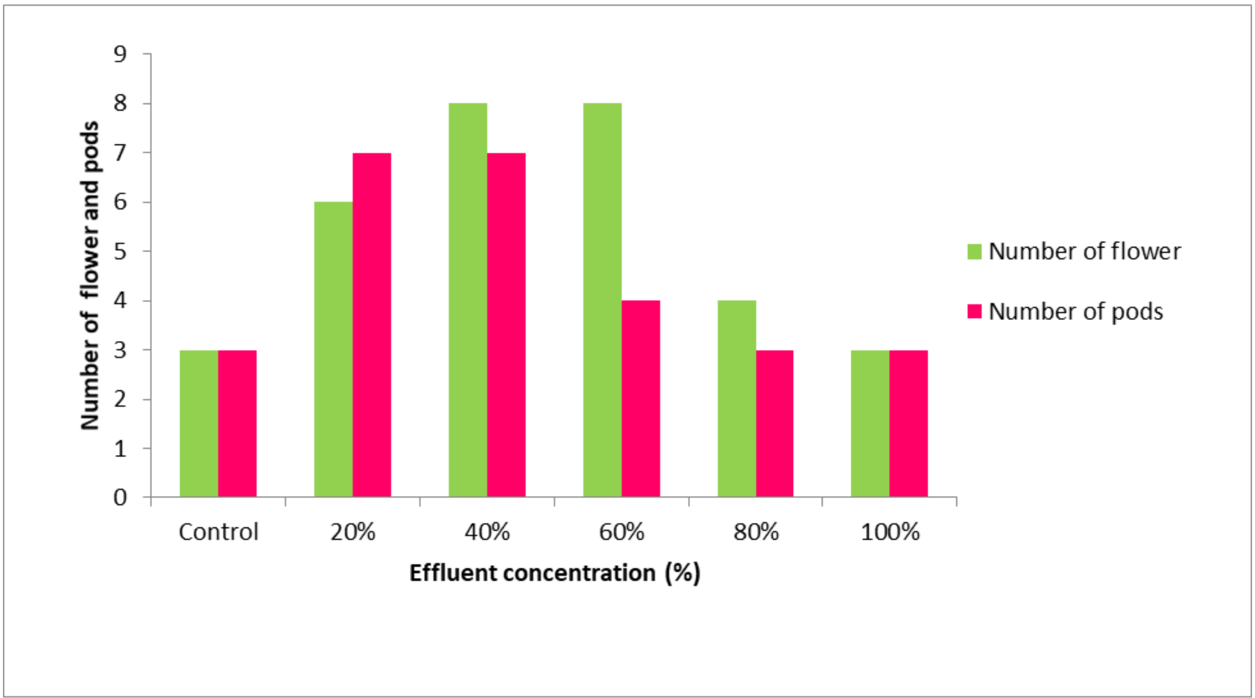

Table 5: Effect of domestic sewage effluent on the yield parameters of *Vigna radiata* (L.) Wilczek

Various Concentration	*Length of pod (cm)	*Number of seeds per pod	*Fresh weight(gm)	*Dry weight(gm)
Control	7.33 ± 0.737	7.00 ± 0.577	1.66 ± 0.288	0.21± 0.080
20%	8.03 ± 0.230	8.00 ± 0.577	2.00 ± 0.000	0.39 ± 0.115
40%	8.00 ± 0.000	7.00 ± 2.645	1.99 ± 0.000	0.58 ± 0.034
60%	7.53 ± 0.461	7.00 ± 1.154	1.43 ± 0.288	0.46 ± 0.057
80%	6.66 ± 0.577	6.00 ±0.577	1.33 ± 0.577	0.26 ± 0.023
100%	5.86 ± 0.115	4.00 ± 1.154	0.66 ± 0.288	0.10 ± 1.699

* Replicates of three

Yield studies

Yield studies showed that sewage effluent showed better yield at lower concentration of the effluent treated plants whereas higher concentration above 60 % showed detrimental effect. The sewage effluent treated plants showed maximum number of flowers (8 ± 0.000, 8 ± 0.577) and pods (7 ± 0.000, 7 ± 0.577) in 40% and 60% concentrations. The length of the pods (8.03 ± 0.230 cm) and the number of seed per pod (8.00 ± 0.577) were more in 20 % concentration. Fresh and dry weight of the pod showed a maximum value in 40% concentration. The recorded value was 1.99 ± 0.000 gm and 0.58 ± 0.034 gm.

A marked increase was observed in number of flowers, fruits, fresh weight and dry weight and length of the fruits in both the effluent treated plants. Alizadeh *et al*. (2001) also reported that irrigation treatment with waste water cause more biological yield of *Zea mays*. The increase in yield in the present study showed that the organic substance present in the domestic sewage effluent supports the growth of plants with some limitations. If excess amount of organic matters serve as toxic material, it will prevent the growth of experimental plant. Fasciola *et al*. (2002) also obtained similar higher yield of *Allium sepa* L. and *Allium sativum* L. with sewage effluent.

Conclusion

The results of the present findings showed a most significant increase in morphological, biochemical, physiological and yield parameters in the effluent treated plants during the study period. Higher concentration of the effluent treated plant however showed a retardation effect. The domestic sewage effluent treated plants showed significant growth. The study demonstrated that upto 60% sewage effluent could enhance and promote morphological, biochemical, physiological and yield parameters. From the above findings it can be concluded that the *Vigna radiata* (L.) Wilczek selected for the study was least affected by domestic sewage effluent. On the basis of this preliminary work it can be suggested that domestic sewage effluent can be used in agriculture for irrigational purpose. The benefits of wastewater use in irrigation are numerous but precautions should be taken to avoid short and long term environmental risks.

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