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RESEARCH ARTICLE

IMPACT OF INDUSTRIAL POLLUTION ON PHYSIOLOGICAL GROWTH AND NUTRIENT CONTENTS OF COMMON GREEN LEAFY VEGETABLES

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ABSTRACT

The agriculture has been always remaining as backbone of economy. Maintenance of soil and water quality has been pointed out as one of the major contributing factors for sustainability of agricultural production. Conserving the water sources and agricultural lands for getting non-toxic food from plants, the present study has undertaken to investigate the mineral composition and vitamin contents of green leafy vegetables as well as the effect of pollution on plant physiology. Normal soil and water, Industrial non - recycled water and soil were collected from the Thekkampatti village of Karamadai, Coimbatore district, Tamil Nadu. Industrial recycled water and soil have collected from the Otterpalayam (Annur) of Coimbatore district, Tamil Nadu. The result indicates that industrial non recycled water possess pH of 8.9 shows alkalinity. Industrial water non recycled soil the Chromium (58.0 mg/L) is present in higher quantity. The germination percentage was desirably good in normal soil and followed by water recycled soil cultivated green leaves. In non-recycled soil it was delayed the germination and percentage also very poor. In case of *Amaranthus polygonoides*, the germination was completely inhibited by the water recycled soil as well as water non-recycled polluted soil. The impact of pollution present in the non-recycled soil was clearly observed in respective plant leaf numbers, size and shoot length. The present study is also one of the attempts to prove the importance of recycling of industrial pollution as well as the impact of non-recycled heavy metal pollution in common green leafy vegetables growth and nutrients. The industries should follow the recycling process based on the chemicals utilized for their products. The soil and water are need to conserve with efficient recycling methods in order to prevent the pollution which in turn becomes health hazards for the human and other living organisms through crop plants.

Keywords: Pollution, waste recycling, bioaccumulation, nutrition effect, growth effect

1. INTRODUCTION:

The agriculture has been always remaining as backbone of economy. Maintenance of soil and water quality has been pointed out as one of the major contributing factors for sustainability of agricultural production [1]. Water is essential natural resource for sustaining life and environment, which is always thought to be available in abundance and free gift of nature. For a long time people utilized water through natural resources like well, lake, and river etc. But today most of the water resources are exploited without proper maintenance and polluted by human activities and those resources are became unfit for use. Textile industries are one of the major consumers of water and disposing large volumes of effluent to the environment. Since, textile industry utilizes abundant water in dyeing and finishing processes, there is an immediate need to adopt economical practices for the use of water in textile industries [2].

The surface water sources are limited and availability of water vary from year to year depending upon monsoon conditions. The underground water resources are also getting depleted with increasing amount of water drawn from them every year without adequate replenishments. Therefore, the cost of water is rising steeply [3].

The wet processing part of the industry pre –treatment, dyeing, printing and finishing, is especially polluting and resource consuming in terms of water, energy and chemicals. Separation techniques like membrane filtration have been applied successfully to the process water used in wet processing in both cotton and polyester dyeing. Pilot scale demonstration plants have documented the technical feasibility of water reclamation by this technique [4]. Reclaimed or recycled water is the process of converting wastewater into water that can be reused for other purposes like irrigation of gardens and agricultural fields or replenishing surface water and ground water [5]. In industrial wastes and effluents without treatments it contains heavy metals like Cu, Zn, Pb, Cr, Cd, Mn, and Fe. Some of them are toxic to both plants and animals. The accumulated heavy metals will causes the health

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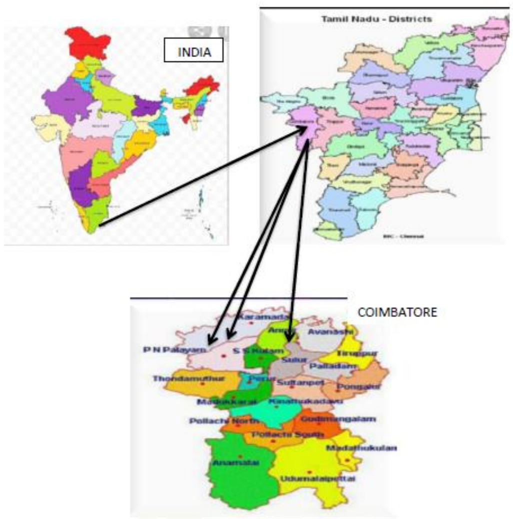
effects when human consumption. In areas where irrigation water is scarce, the use of industrial wastewater is an important source for supplementing water resources [6].

In addition to that, green leafy vegetables occupy an important place among the food crops as they provide adequate amounts of many vitamins and minerals for human health [7]. In deficiency of these essential vitamins and minerals causes irreparable health problems and it will affect the life quality of human beings. The heavy metal accumulations due to the industrial wastes are dangerous to the living things. So, the evaluation of pollution remnants in five different type of green leaves such as an *Amaranthus cruentus* L. (Amaranthaceae), *Trigonella foenum-graecum* L. (Fabaceae), *Digera muricata* (L.)Mart (Amaranthaceae), *Amaranthus polygonoides* L. (Amaranthaceae) *Celosia argentea* L. (Amaranthaceae) are in need.

Based on the fundamental and necessity of conserving the water sources and agricultural lands for getting non-toxic food from plants, the present study has undertaken to investigate the mineral composition and vitamin contents of green leafy vegetables as well as the effect of pollution on plant physiology.

2. MATERIALS AND METHODS

Normal soil and water, Industrial non - recycled water and soil were collected from the Thekkampatti village of Karamadai, Coimbatore district, Tamil Nadu. Industrial recycled water and soil have collected from the Otterpalayam (Annur) of Coimbatore district, Tamil Nadu.



2.1. Soil and water sample collection method

In study area of the field was divided into different homogenous unit based on the visual observation remove the surface litter at the sampling spot drive the auger to a plough depth of 15cm and draw the soil sample and collect at least 10 to 15 samples from each sampling unit and place in a bucket make a " V shaped cut to a depth of 15cm in the sampling spot using spade remove thick slices of soil from top to bottom of exposed face of the V" shaped cut and place in clean container. The quartering is done by dividing the thoroughly mixed sample in to 4 equal parts, the two opposite quarters are discarded and the remaining two quarters are remixed and the process repeated until the desired sample size is obtained collect the sample in a clean polythene bag [8].

The tap water was collected as water sample and stored in glass container. When water is drawn from an underground source, allow the pump to run for sufficient time to flush out water which has been in the pipe, then take samples at time intervals of 5-10 minutes, from the first off take point, e.g., tap, trough, or sprinkler head [9].

2.2. pH analysis of soil and water

Weigh 50 g air dry soil (< 2mm) into a 100 mL glass beaker and add 50 mL deionised water using a graduated cylinder or 50 mL volumetric flask. Mix well with a glass rod, and allowed to stand for 30 minutes. Stir suspension every 10 minutes during this period. After 1 hour, stir the suspension and took the reading after 30 seconds with one decimal [10]. A 50mL water sample was taken in 100 mL flask, and observed the reading after 30 seconds.

2.3. Heavy metal analysis

1g of the shade dried sample was weighed and placed in 250 mL beakers separately to which 15 mL of aquaregia (35% HCL and 70% high purity HNO, in 3:1 ratio) were added. The mixture was then digested at 70°C till the solution became transparent. The resulting solution was filtered through whatsman filter paper no. 42 and dilute into 50mL and to mark the volume using deionised water and the sample solution was analyse for concentrations of Cadmium, Chromium, Nickel and Lead using an atomic absorption spectrophotometer (Perkin–Elmer AAS analyst 400). The metal concentrations from the sample solution were determined from the calibration, based on the absorbance obtained for the unknown sample [11].

2.4. Preparation of green leaves

The vegetable leaves are used for studied which were harvested fresh; washed with tap water and shade dried. After drying, the leaves were ground into a fine powder and stored in air-tight containers.

2.5. Determination of Vitamin C

Ascorbic acid determination was carried out according to the method of Klein and Perry [12]. About 10 mg of dried plant powder were extracted with 10 mL of 1% metaphosphoric acid. They were allowed to stand for 45min at laboratory temperature and filtered through Whatsman No.1 filter paper. About 1mL of filter was taken and it was mixed with 9mL of 50 μmol/L 2.6-dichloroindophenol sodium salt hydrate and the absorbance was measured within 30min at 515nm. Ascorbic acid content was calculated on the basis of the calibration curve of authentic L-ascorbic acid and the results were expressed as mg of ascorbic acid equivalent (mg AE/g extract).

2.6. Determination of calcium (Ca) [13]

Morgan's Reagent: 30 mL of glacial acetic acid and 100 grams of Sodium acetate are dissolved in distilled water.

Plant sample (0.5g) is taken into a glass vial and 5 mL of Morgan‟s reagent is added in test tube. After allowing it to stand for 15 min, 2 mL of glycerine and 5 mL of 10% ammonium oxalate is added and the solution is shaken for 2 min and absorbance at 512 nm was read against the blank.

2.7. Determination of magnese (Mn) [13]

About 5mL of the sample was pipette into a test tube in duplicate and 0.25mL of concentrated Sulphuric acid was added and incubated for 1 hour in boiling water bath. A spatula tip full sodium per- iodate was added and was heated for another 10 minutes, cooled and the absorbance was taken at 520nm against the blank.

2.8. Determination of iron (Fe) [13]

About 0.5g of the sample taken in to a glass vial and 1mL of conc. HCl is added, after 15 minutes 10 mL of distilled water and 2-3 drops of conc. Nitric acid are added. 10 mL of the solution pipetted out into a specimen tube after 2 min and 5 mL of 20% ammonium thiocynate is added and stirred. Further, 2 mL of Amyl alcohol is added, shaked well and allowed to stand for few minutes and absorbance was taken at 520 nm against the blank.

3. 3. RESULTS AND DISCUSSION

3.1. pH level of soil and water

When soil and water meet their acidity levels interact and combine to influence both. The present study of soil and water sample collected and analyzed the property of pH and given in Table 1. The pH values of the normal soil is 6.5 (neutral level), industrial water recycled soil is 6.8 (neutral level) and industrial water non- recycled soil is 8.7 (strongly alkaline). Similarly, normal water have the pH value is 7.1(neutral level), industrial recycled water pH is 7.5 (alkaline) and industrial non recycled water pH is 8.9 (strongly alkaline).

The optimum range of pH for plant growth is from 6.0 to 8.0. A major problem for many agricultural areas is increasing alkaline associated with pasture improvement and the removal of agricultural products from the landscape [14].

Table 1. *pH* Levels of collected Soil and Water

Samples	**pH levels**		
	Normal area	**Industrial waste water Recycled area**	**Industrial waste water non-recycled area**
Soil	6.5	6.8	8.7
Water	7.1	7.6	8.9

3.2. Heavy metals in soil samples

In present study, the normal soil, industrial water recycled soil, industrial water non recycled soil heavy metals were above 50 mg/L is considered as highly polluted with heavy metals and below 50 mg/L indicates the low level of heavy metal. The particular heavy metals like Cadmium (Cd), Chromium (Cr), Lead(Pb) and Nickel(Ni) were analysed and tabulated (Table 2). Normal soil and industrial water recycled soil heavy metals are BDL (Below Detectable Limit) but industrial water non recycled soil the Chromium (58.0 mg/L) is present in higher quantity.

In previous publication, the soil samples were collected from 4 different areas, such as river sites, institutional area, urban area, industrial area. In all the soil samples Mn concentration is higher than the permissible limit (20 ppm). The higher concentration of Mn not only diminish soil quality, but also can lead to human intake through the tropic food web and harm to human health [15].

Table 2. Heavy Metals in the Soil

S. No	Parameters	Normal Soil	Industry Water Recycled Soil	Industry Water Non Recycled Soil
1.	Total Cadmium (mg/L)	BDL	BDL	BDL
2.	Total Chromium (mg/L)	BDL	BDL	58.0
3.	Total Lead (mg/L)	BDL	BDL	3.20
4.	Total Nickel (mg/L)	BDL	BDL	4.70

BDL - Below Detectable Limit; ≤ 50.0 High level; ≥ 50.0 Neutral level

PLATE I: SELECTED GREEN LEAFY VEGETABLES

1. *Amaranthus cruentus* L.

2. *Trigonella foenum-graecum* L.

3. *Digera muricata* (L.)Mart.

4. *Amaranthus polygonoides* L.

5. *Celosia argentea* L.

PLATE – II : GROWTH OF GREEN LEAVES - ON 5th DAY

A. NORMAL SOIL

B. WATER RECYCLED SOIL

C. WATER NON RECYCLED SOIL

GROWTH OF GREEN LEAVES ON 15th DAY

A.NORMAL SOIL

B. WATER RECYCLED SOIL

C. WATER NON RECYCLED SOIL

3.3. Physiological parameters of green leafy vegetable

In previous literature, fresh and polluted water had significant effect on straw yield of Boro rice in both fresh and polluted soils (Table 4). In fresh soil, the highest straw yield (5.42 t/ha and 5.57 t/ha) was recorded from fresh water as irrigation followed by mixed water (4.34 t/ha and 4.40 t/ha). The lowest straw yield (3.02 t/ha and 3.13 t/ha) was recorded with polluted irrigation water. Similarly in polluted soil, highest straw yield (2.59 t/ha and 2.68 t/ha) was found from fresh water irrigated followed by mixed water (2.01 t/ha and 2.07 t/ha). The polluted water recorded the lowest straw yield (1.36 t/ha and 1.40 t/ha). Results clearly indicate that textile industrial waste water was detrimental to rice growth and always gave the poor straw yield of Boro rice even in the fresh soil [16] where they observed that toxicity of heavy metals (As, Cu, Hg, Zn, Cd, Cr, Pb, Mo, Ni, and Se) decreased plant growth and development.

In present study, the physiological parameters like germination percentage, shoot length, leaf size and numbers were observed. The germination percentage of water non recycled polluted soil and water recycled soil cultivated green leaves were compared with normal soil cultivated green leaves, where the percentage was desirably good in normal soil and followed by water recycled soil cultivated green leaves. Particularly, *Amaranthus cruentus* shows the best % of germination in normal soil (86%) but in water recycled soil (79%) and water non-recycled polluted soil (25%) inhibits the germination visibly. Similarly, the *Trigonella foenum-graecum* shows the good percentage of germination in normal soil (83%) where the percentage was very much minimized in polluted soil (38%) (Table 3). In *Amaranthus polygonoides*, the germination was completely inhibited by the water recycled soil as well as water non-recycled polluted soil. The other green leaves like *Digera muricata, Celosia argentea* and *Amaranthus polygonoides* are not germinated in recycled as well as non-recycled soil. The first two are not germinated even in normal soil, it may be due to the seed quality and viability.

In present study, there are three green leaves were germinated out of five selected, the shoot length have noticed on 5th, 10th and 15th day after sown. Significantly, on 15th day *Amaranthus cruentus* shows great difference in shoot length in normal soil (19.9 cm) when compared to water non-recycled polluted soil (4.96 cm) (Table 4). During the observation, the number of leaves has also noticed on 5th, 10th and 15th day. The impact of pollution present in the non-recycled soil was clearly observed in respective plant leaf numbers. Significantly, on 15th day the *Amaranthus cruentus* shows good number of leaves on normal soil followed by water recycled and water non-recycled soil greens. In *Trigonella foenum-graecum*, there was no such difference between the normal soil (15 nos) and water recycled soil (15 nos.) but in water non-recycled soil the number of leaves produced are very much less (3 nos.) (Table 5).

The length of mature leaves of *Amaranthus cruentus* were observed on 5th , 10th and 15th day and the values are almost same in both normal and water recycled soil cultivated green leaves (9.4±0.90cm and 9.0±0.70cm respectively) whereas, the polluted water non-recycled soil cultivated leaves size was very much reduced (2.5±0.63cm). Similarly in *Trigonella foenum-graecum* leaf size values are almost same in both normal and water recycled soil cultivated green leaves (3.7±0.97 and 3.5±0.76 cm respectively) whereas, the polluted water non-recycled soil cultivated leaves size was very much reduced (1.9±0.03cm) (Table 6).

Table 3. Physiological Parameters - Germination Percentage of Green Leaves

S. No.	Plant Name	Sowing Date	Germination Day	% of Germination
		NORMAL SOIL		
1.	*Amaranthus cruentus*	31/12/2019	4th Day	86%
2.	*Trigonella foenum-graecum*	31/12/2019	2nd Day	83%
3.	*Digera muricata*	31/12/2019	--	--
4.	*Celosia argentea*	31/12/2019	--	--
5.	*Amaranthus polygonoides*	31/12/2019	7th Day	52%
		INDUSTRY WATER RECYCLED SOIL		
1.	*Amaranthus cruentus*	31/12/2019	4th Day	79%

2.	*Trigonella foenum-graecum*	31/12/2019	2nd Day	81%
INDUSTRY WATER NON RECYCLED SOIL				
1.	*Amaranthus cruentus*	12/2/2020	4th Day	25%
2.	*Trigonella foenum-graecum*	12/2/2020	3rd Day	38%

Table 4. Shoot Length of Green Leafy Vegetables (Cm)

S. No	Plant Name	5th Day	10th Day	15th Day
		NORMAL SOIL		
1.	*Amaranthus cruentus*	3.17±0.45	6.7±0.83	19.9±0.19
2.	*Trigonella foenum-graecum*	3.63±0.76	7.73±0.27	12.03±0.15
3.	*Amaranthus polygonoides*	Germinated on 7th day	2.1±0.39	9.23±0.52
		INDUSTRY WATER RECYCLED SOIL		
1.	*Amaranthus cruentus*	2.86±0.52	6.6±0.73	19.7±0.99
2.	*Trigonella foenum-graecum*	3.43±0.85	7.6± 0.83	11.3±0.22
INDUSTRY WATER NON RECYCLED SOIL				
1.	*Amaranthus cruentus*	0.83± 0.11	3.0±0.38	4.96±0.62
2.	*Trigonella foenum-graecum*	1.6±0.97	3.23±0.435.4±0.53	

*Values are mean ± SD of 10 plants from each green leafy vegetable.

Table 5. Number of Leaves sprouted from Green Leafy Vegetables

S. No.	Plant Name	5th Day	10th Day	15th Day
		NORMAL SOIL		
1.	*Amaranthus cruentus*	2	5	12
2.	*Trigonella foenum-graecum*	2	4	15
3.	*Amaranthus polygonoides*	--	7	17
		INDUSTRY WATER RECYCLED SOIL		
1.	*Amaranthus cruentus*	2	5	10
2.	*Trigonella foenum-graecum*	2	3	15
		INDUSTRY WATER NON RECYCLED SOIL		
1.	*Amaranthus cruentus*	2	4	6
2.	*Trigonella foenum-graecum*	2	3	3

Considered the maximum plants in a group possessing the leaf as number

Table 6. Leaf Length of Green Leafy Vegetables (Cm)

S.No	Plant Name	5th Day	10th Day	15th Day
		NORMAL SOIL		
1.	*Amaranthus cruentus*	1.8±0.12	5.6±0.99	9.4±0.90
2.	*Trigonella foenum-graecum*	1.53±0.78	3.0±0.16	3.76±0.97
4.	*Amaranthus polygonoides*	Germinated on 7th day	1.76±0.16	2.9±0.98
		INDUSTRY WATER RECYCLED SOIL		
1.	*Amaranthus cruentus*	1.46±0.93	5.6±0.99	9.0±0.70
2.	*Trigonella foenum-graecum*	1.33±0.64	2.9±0.03	3.53±0.76
		INDUSTRY WATER NON RECYCLED SOIL		
1.	*Amaranthus cruentus*	0.25±0.97	1.9±0.89	2.5±0.63
2.	*Trigonella foenum-graecum*	0.13±0.53	1.75±0.93	1.9±0.03

*Values are mean ± SD of 10 plants from each green leafy vegetable.

Table 7. Mineral Composition of Green Leaves

S.NO	MINERAL (mg/100mL)	*Amaranthus cruentus*	*Trigonella foenum- graecum*	*Amaranthus polygonoides*
		NORMAL SOIL		
1.	Calcium (Ca)	1.259±0.354	1.257±0.294	0.554±0.843
2.	Iron (Fe)	2.618±0.650	0.585±0.601	0.849±0.949
3.	Manganese (Mn)	0.973±0.059	0.530±0.539	2.487±0.506
		INDUSTRY WATER RECYCLED SOIL		
1.	Calcium (Ca)	0.792±0.892	1.236±0.273	--
2.	Iron (Fe)	0.778±0.124	0.874±0.563	--
3.	Manganese (Mn)	0.905±0.938	0.753± 0.982	--

Values are mean ± SD of three independent Experiments.

3.4 Nutrient analysis

The estimation of Vitamin C and minerals like Ca, Fe and Mn were evaluated on collected green leafy vegetable plant powder sample. Estimation of Vitamin C fluctuated among the plant samples and the results shows *Amaranthus cruentus,* have almost same quantity in both normal soil and water recycled soil (1.202±0.25 mg AAE/g and 1.197±0.25 mg AAE/g respectively) but, In *Trigonella foenum-graecum,* the observed values are in normal soil is 1.84±0.85 mg AAE/g whereas, the industrial water recycled soil cultivated plant possessing 1.57±0.63 mg AAE/g. Hence the study suggest, the polluted recycled water is the second grade water even for the agriculture purposes. It also can diminish the nutrition quantity of plant based food. In previous study, *Solanum nigrum* having good quantity of vitamin C (3.18mg/100mL) when compared to *Mucuna pruriens* (0.08mg/100mL). Vitamin C is a potent antioxidant that facilitates the transport and uptake of non-heme iron at the mucosa, the reduction of folic acid intermediates and the synthesis of Cortisol. Its deficiency includes fragility to blood capillaries gum decay, scurvy and etc. [17].

Estimation of Minerals like Ca, Fe and Mn in *Amaranthus cruentus* were carried out for the powder sample of green leaves where the values are Ca (1.259ppm), Fe (2.618ppm), and Mn (0.973 ppm) in normal soil are comparably reduced in industrial water recycled soil cultivated greens (Ca -0.792mg/100mL, Fe -0.778mg/100mL, and Mn -0.905 mg/100mL respectively). In case of *Trigonella foenum-graecum,* the minerals were observed as Ca (1.257 mg/100mL), Fe (0.585 mg/100mL) and Mn (0.530 mg/100mL) in normal soil, and industrial water recycled soil cultivated green minerals Ca (1.236 mg/100mL), Fe (0.874 mg/100mL) and Mn (0.753 mg/100mL) were observed where Fe and Mn were much greater in later case (Table 7) which might be due to the impact of wastes from industry which is need to evaluate further for finding the reason. Sometimes there is an excess of nutrients in the water which causes an excess in plant growth. Other times this excess in nutrients in the water causes a fluctuation in acidity and damages or kills the plant [18].

By this study, the result suggests the waste water recycling and similar methods to treat water before discharge. Utilization of recycled industrial waste water is of course appreciable, but should maintain a suitable distance from any watercourse are to be followed in order to avoid the ill effects.

4. CONCLUSION

The findings of the present study revealed that the industrial water non-recycled soil highly affect the growth of plants due to the presence of various heavy metals. Sometimes there is an excess of nutrients in the water which causes an excess in plant growth and also causes a fluctuation in soil acidity and damages the plant . Hence, it could be concluded that the industrial water should be recycled before enter in the environment. The present study is also one of the attempts to prove the importance of recycling of industrial pollution as well as the impact of non-recycled heavy metal pollution in common green leafy vegetables growth and nutrients. The industries should follow the recycling process based on the chemicals utilized for their products. The soil and water are need to conserve with efficient recycling methods in order to prevent the pollution which in turn becomes health hazards for the human and other living organisms through crop plants.

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