

COMPARATIVE BIOCHEMICAL PROFILE OF GREEN VEGETABLES GROWN IN CONTROLLED AND POLLUTED WATER

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ABSTRACT

The biochemical profile of the green vegetables is being compared which is grown in controlled and polluted water of Drvyawati river, Jaipur. These biochemical attributes were studied on the basis of quantification of Ascorbic acid, Lipid, Protein, Starch, Total soluble sugars, Chlorophyll, Carotenoids and Nucleic acids (DNA/RNA). Two economically important plants namely Radish (*Raphanus sativus* L. var. Daikon, "Japani white") and Brinjal (*Solanum melongena* L. var. *esculentum*, "PPL/PPR") Omaxe hybrid seeds commercially supplied by Raunak Seeds Limited, New Delhi were taken as experimental material. In this article, the toxic effects of industrial effluents on the growth and various biochemical characteristics on these vegetables were studied. The outcome of quantitative analysis of primary metabolites and other biochemical characteristics in whole plants as well as fruits grown in control and polluted water conditions have suggested that the water quality is not suitable for irrigation and increases the level of toxicity in vegetable crops.

KEYWORDS: *biochemical, quantification, industrial effluents, metabolites*

INTRODUCTION

The primary metabolites are the most significant characteristics to study the level of manipulated levels of toxicity in the agricultural field due to drainage of industrial effluents from water bodies. The polluted water contains various heavy metals that results in toxicity. The effect of lead on the phytochemistry of *Tithonia diversifolia* exposed to road side automotive pollution leads to detrimental toxicity in environment. The concentration of Pb in leaves and roots of plants from heavy traffic roadside was higher than of plants from light traffic site. The content of Cr, Al, Fe, Cu and Ni was also higher in leaves but not in root plants from the polluted site. Pb contaminated leaves and roots showed higher acid phosphatase activity while the foliar nitrate reductase activity and specific leaf mass were lower and an increase of leaf phenol concentration was observed¹. The impact of sugar factory waste water on chlorophyll content disturbs carbohydrate and biomass production of *Triticum aestivum* var. Malvia-212. It was found that concentrated effluents reduced all these contents significantly and it was attributed to the reduced number of leaves and leaf area. The reduced growth

and biomass was result of high concentration of soluble salts and heavy metals². The influence of zinc on physiological and biochemical parameters was studied to elucidate the mechanism of Zn resistance in *Phragmites australis*. Zn concentrations in roots, stems and leaves increased with exogenous Zn concentration, while Zn content in roots was much higher than in shoots³. Accumulation of polycyclic aromatic hydrocarbons (PAHs) and heavy metals (HMs) reported in crop plants from contaminated soils were observed. A greenhouse pot experiment using lettuce (*Lactuca sativa*) as a representative vegetable was conducted to assess the concentrations of PAHs and HMs in vegetables grown in wastewater-contaminated soils. This study highlighted the potential health risks associated with cultivation and consumption of leafy vegetables on wastewater-contaminated soils⁴. The biochemical changes were investigated in isolated roots of *Phragmites australis* treated with industrial waste water. *Phragmites australis* is a plant that adapts well to oxidative stress generated by waste water from industrial sources resulted in high levels of proline (indicator parameter of stress). This stress caused the activation of detoxification involving the use of anti-oxidant

enzyme activities, confirmed by stimulating the synthesis of total protein and by inhibition of respiratory metabolism of the plant⁵. Pigment concentration and biochemical parameters for *Brassica juncea* L. in response to cadmium and lead stress confirmed higher levels of toxicity⁶. Heavy metals are essential and important for plants growth, and play a role as key components of many vital compounds. However, on increase in their concentration, the plants showed symptoms such as growth delay and inhibition of biochemical reactions⁷. Chemical analysis of carbohydrates showed significant increase in the contents of reducing sugars in response to lead, cadmium and nickel stress, which were decreased by liming treatments. The contents of total soluble sugars also increased in plants irrigated with polluted water containing various heavy metals. Polluted water containing various heavy metals significantly lowered the leaf contents of the photosynthetic pigments (chlorophyll-a, chlorophyll-b and carotenoids). The sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) of proteins indicated variations in the profile of electrophoretic protein bands in heavy metal-stressed common bean plants before and after liming.

MATERIALS AND METHODS

The Control sites were Department of Botany, University of Rajasthan (Site-I) and Shikarpura, Sanganer (Site - II) and the polluted sites were Govindpura (Jotadawala), Sanganer (Site - III) and near Shikarpura Flyover, Sanganer (Site-IV) of Amanishah Nalla. Plant materials were collected from the plants raised both from control as well as polluted sites for biochemical analysis. These experiments were performed on radish and brinjal separately by considering average values for different parameters.

Carbohydrates

Extraction Procedure

Total Soluble Sugars

Each of the dried and powdered test sample (50 gm) was macerated in a mortar and pestle with 20 ml of 80% ethanol and left overnight. Each of the homogenates was centrifuged (1200 rpm, 15 min). The supernatants were removed and concentrated on a water bath. Later each resultant concentrate was raised to 50 ml with distilled water and processed further following the method for total soluble sugars.

Starch

For starch, the residual pellet obtained out of the above process in each case was suspended in 5 ml of 52% perchloric acid and 6.5 ml of distilled water, shaken vigorously (5 min) and then centrifuged (2500 rpm)⁸. This step was repeated thrice and the supernatant of each sample were pooled together and the volume was raised to 100 ml with distilled water. Out of this, 1 ml aliquot was measured separately to estimate starch quantitatively.

Quantification

Aliquots (1 ml) of each test sample were used to estimate quantitatively the total levels of carbohydrates following the protocol using phenol-sulphuric acid reagent, which included the preparation of a regression curve for the standard glucose⁹.

Ascorbic acid

Extraction procedure

Each of the fresh experiment materials (400 mg) was homogenized thoroughly with 10 ml of acetate buffer (pH 4.8) and centrifuged (1200 rpm, 20 min.). The supernatants were separately collected, out of which 1 ml was measured to other test tube; 4 ml of 4% tri-chloro-acetic acid (TCA) was added, left overnight and later, centrifuged. To the supernatant of each sample, 1 ml of the colour reagent (prepared by mixing 90 ml of 2.2%, 2,4-dinitrophenylhydrazine in 10N H₂SO₄, 5 ml of 5% thiourea and 5 ml of 0.6% CuSO₄ solution), was added and incubated at 57° for 45 min. Later, on cooling 7 ml of 65% H₂SO₄ was added to each mixture and cooled again⁹.

Quantification

From the stock solution of ascorbic acid (10 mg/100 ml in 4% TCA), varied concentrations (0.01 to 0.09 mg/ml) were prepared in different test tube. The volume of each was raised to 5 ml by adding 4% TCA solution and left overnight at the room temperature. Later, to each of these, 7 ml of 65% H₂SO₄ was added, brought to the room temperature and the ODs were measured at 540 nm in a spectrophotometer against a blank.

Lipids

Extraction and Quantification

Each of the dried and powdered test samples (1g) was homogenized using a mortar and pestle with 10 ml distilled water¹¹.

Proteins

Extraction Procedure

Each of the dried test samples (60 mg) was measured in 10 ml of cold 10% TCA solution (30 min), kept at 4°C overnight and centrifuged. The supernatants were discarded in each case and the resultant pellet of each was re-suspended in 10 ml of 5% TCA solution and heated at 80°C in a water bath for 30 min. These samples were cooled, re-centrifuged and the supernatant so obtained were discarded each time. The pellet was then washed with distilled water and centrifuged. Each of the residues left after the centrifugation was dissolved in 10 ml of 1N NaOH and left overnight at room temperature¹².

Quantification

Using 1 ml aliquot of extract, total phenol contents were estimated following the method of Lowry *et al.*¹³.

Nucleic acids

DNA Isolation

One gram of tender twigs along with leaves was homogenized in absolute alcohol. The homogenized material was handled as per the standard protocol¹⁴.

Purification of DNA

RNA was removed by treating the sample with DNase free RNase procured from Pure-gene, USA. Protein including RNase was removed by treating with chloroform, Isoamyl alcohol (24:1). The purification was carried out in following steps: 25 µl of RNase was added to 0.5 ml of crude, DNA preparation (2.5 µl of RNase = 25 µg of RNase, so treatment was 50 µg / ml of DNA preparation).

Gently it was mixed thoroughly and was incubated at 37°C for 1hr. After 1 hr, a mixture of 0.3-0.4 ml of chloroform: Isoamyl alcohol (24:1) was added and mixed thoroughly for 15 minutes till an emulsion was formed and spun for 15 minutes at 15,000 rpm. Supernatant was taken avoiding the whitish layer at interface. The DNA was re-precipitated by adding double the quantity of absolute alcohol. To pellet the DNA, the tube was centrifuged for 5 minutes at 5,000-10,000 rpm. The pellet was washed with 70% alcohol and dried overnight. The DNA was re-dissolved in 500 µl of TE buffer.

Gel Analysis

The integrity of DNA was judged through gel analysis in following steps:

Cast 150 ml agarose gel (0.8%) in 0.5X TBE (Tris Borate EDTA) buffer containing 0.5 µg / ml of Ethidium Bromide. 2 µl of DNA per sample was loaded in each well. Known amount of uncut Lambda phage DNA was also loaded as control. Electrophoresis was conducted at 50V for 1 hr. Gel was visualized under UV light using Trans illuminator. Presence of single compact band at the corresponding position to λ phage DNA indicates high molecular weight of isolated DNA.

Quantization of DNA

The quantization of DNA was done by observing it at 260 nm and 280 nm wavelengths by using a UV-VIS spectrophotometer in following steps:

200 µl T.E. buffer was taken in a cuvette and spectrophotometer was calibrated at 260 nm as well as at 280 nm wavelengths. Added 4µl DNA mixed properly and record the absorbance (A) at both 260 and 280 nm. DNA concentration was estimated by employing the following formula:

$$\text{Amount of DNA}(\mu\text{g}/\mu\text{l}) = \frac{A_{260} \times 50 \times \text{dilution factor}}{1000}$$

Quality of DNA judged from the ratio of A values recorded at 260 and 280 nm.

RNA

Acid-guanidinium thiocyanate-phenol-chloroform RNA purification method¹⁵.

Photosynthetic pigments (Chlorophylls and carotenoids)

Extraction Procedure

The fresh experimental materials (1g each) were homogenized in 40 ml of 80% acetone, to which a

pinch of NaHCO₃ was added to prevent any pheophytin formation¹⁶. This extraction was carried out in the dim light conditions to avoid any photobleaching¹⁷. Each sample was centrifuged and the supernatant was collected separately. For the complete extraction of pigments, this step was repeated thrice and the supernatants were collected separately. For the complete extraction of pigments, this step was repeated thrice and the supernatants of each were pooled separately and of which was raised to 80% acetone individually.

Quantification

The ODs of each of the above extracts were recorded at 652, 663 and 480 nm with a spectrophotometer against 80% acetone as the

blank. Five such replicates at each wavelength were chlorophyll a band, the total present in the samples was calculated in mg/g of plant material from the equations derived¹⁸.

$$\text{Chlorophyll a} = \frac{11.3A_{663} - 0.96A_{645} \times V}{a \times 1000 \times w}$$

$$\text{Chlorophyll b} = \frac{18.3A_{645} - 3.9A_{663}}{a \times 1000 \times w}$$

$$\text{Total Chlorophyll} = \frac{A_{652} \times V}{34.5 \times w}$$

(Where, A = Absorbance; V = Volume of each extract; w = weight of the plant material used; a = the length of light path in the cell which is usually 1

cm). Similarly, the level of total carotenoids (mg/g) was calculated during the equation given by¹⁹ where E is determined as follows.

$$\Delta E \text{ Car}_{480} = [\Delta E_{480} + (0.114 \Delta E_{663})] - (0.638 \Delta E_{645})$$

(Here, $\Delta E \text{ Car}_{480}$ = increase in absorbance at 480 nm due to carotenoids; ΔE_{480} = extinction at 480 nm; ΔE_{645} = extinction at 645 nm; ΔE_{663} = extinction at 663 nm).

(39.8mg/gdw). Values of lipid contents of whole plant of control and polluted waters are 62 mg/gdw and 61 mg/gdw respectively (Table-1) (Fig. 3-4).

RESULTS

Dried and powdered whole plant vegetative parts and fruits of plants grown in control and polluted waters were extracted for quantification of various primary metabolites in brinjal and radish following the protocols given by earlier workers for total soluble sugars⁸, starch¹¹, lipids⁹, proteins¹³ and ascorbic acid¹⁰. Estimation of nucleic acid - DNA¹⁴ and RNA¹⁵ were carried out using fresh materials. The estimation of chlorophylls and carotenoids was also carried out using fresh materials following¹⁸ and¹⁹ methods respectively.

Quantitative analysis of primary metabolites (in Brinjal) isolated from plants grown in control and polluted water conditions

Ascorbic Acid

Brinjal plants grown in polluted waters contained relatively higher levels of ascorbic acid (whole plant = 0.9 mg/gdw and fruits = 3.4 mg/gdw) as compared to those grown in control conditions (whole plant = 0.35 mg/gdw and fruits = 0.8 mg/gdw) (Fig. 1 and 2) (Table. 1).

Lipids

Increased levels of lipids were estimated in fruits of plants grown in polluted water (59.3mg/gdw) as compared to those growing in control

Proteins

Higher levels of proteins were found in whole plant dried samples (35.6 mg/gdw) as compared to fruits (30.1 mg/gdw). Polluted brinjal fruits contained lowered levels of total proteins (12.6mg/gdw) in comparison to whole plant (38 mg/gdw) (Fig. 5 and 6). (Table 1).

Starch

Starch content was higher in whole plant dried samples (9.8 mg/gdw) as compared to polluted fruits (4.9 mg/gdw). While fruits of plants grown in polluted water contained slightly higher level of starch (10.1mg/gdw) as compared to controls (9.6 mg/gdw) (Fig. 7-8) (Table.1).

Total soluble sugars

Total soluble sugar contents in the control and polluted water are 29.8 mg/gdw and 22 mg/gdw in whole plant samples and 34.5 mg/gdw and 31.0 mg/gdw in fruits respectively. (Table.1)

Total chlorophyll and carotenoids

Higher values of total chlorophyll and carotenoids (1.15 mg/gdw and 0.198 mg/g) respectively were found in control water plants as compared to polluted water ones (Total Chl = 1.01 mg/g; carotenoids = 0.132 mg/g) (Table – 2) (Fig.12).

DNA and RNA

Higher levels of DNA and RNA were found in control water irrigated plants (DNA= 2.98 µg/g; RNA=2.14 µg/g) in comparison to polluted water irrigated plants (DNA=2.15 µg/g; RNA=2.04 µg/g) (Table-2) (Fig. 11).

Pigments

The values for pigments estimated in plants grown in control water condition generally are higher than those grown in polluted water condition. Chlorophyll a, chlorophyll b, total chlorophyll and carotenoids in control and polluted water conditions measured 0.9640, 0.4139, 1.1500 and 0.1980 mg/g and 0.6419, 0.3107, 1.0100 and 0.1320 mg/g respectively (Table. 2).

Quantitative analysis of primary metabolites (in Radish) isolated from plants grown in control and polluted plants

Ascorbic acid

The value of ascorbic acid found in the fruits was slightly lower in control water irrigated plants as compared to polluted water irrigated ones (3.90 mg/gdw and 3.98 mg/gdw respectively) whereas the data estimated from whole plant showed the reverse order (1.60 mg/gdw and 0.8 mg/gdw respectively in control water irrigation and polluted water irrigation conditions) (Table.1).

Lipids

Levels of lipids found in the whole plant grown in polluted water (26.8 mg/gdw) are lower than the plants grown in control conditions (34.5 mg/gdw). Similarly lipid contents (39.1 mg/gdw) recorded in fruits of plants grown in polluted water conditions are lower (43.2 mg/gdw) in comparison to the fruits of plants grown in control conditions (Table.1).

Proteins

Protein contents of whole plant in polluted water conditions (35 mg/gdw) are lower as compared to plants grown in controlled conditions (49.9

mg/gdw). Reverse pattern is seen in fruit samples where fruits of plants grown through polluted water irrigation contained higher (35.9 mg/gdw) level of protein than those grown in control conditions (18 mg/gdw) (Table.1).

Starch

Levels of starch in both whole plants and fruits of plants grown in control conditions and those grown in polluted water conditions remain almost same. Starch values found in fruits and whole plants grown in control conditions and those grown in polluted water conditions are 12.5 mg/gdw and 6.9 mg/gdw and 12.2 mg/gdw and 6.9 mg/gdw respectively (Table.1).

Total soluble sugars

Lower values (18.0 mg/gdw) of total soluble sugars in plants (whole) grown in polluted water are found as compared to controls (19.4 mg/gdw). The total soluble sugar contents in the fruits of control and polluted water irrigated plants were 30 mg/gdw and 32.2 mg/gdw respectively. (Table-1) (Fig. 9-10).

Pigments

Values of total chlorophyll, carotenoids, chlorophyll a and chlorophyll b contents in polluted water irrigated plants (total Chl - 0.4379 mg/g, carotenoids - 0.294 mg/g chlorophyll a 0.3101, chlorophyll b – 0.1439) were lower as compared to control irrigated plants (total Chl - 0.738 mg/g, carotenoids - 0.374 mg/g, chlorophyll a - 0.4319 mg/g, chlorophyll b – 0.3001 mg/g) (Table-2) (Fig.12).

DNA and RNA

The nucleic acids (DNA and RNA) are lower in polluted water irrigated plants as compared to control plants. The concentration of DNA was 3.57 µg/g in control conditions and 0.96 µg/g in and polluted water conditions. Values of RNA content in polluted water irrigated plants and controls were 0.87µg/g and 3.10 µg/g respectively (Table-2) (Fig.11).

Table 1
Quantitative analysis of primary metabolites isolated from control and polluted water irrigated plants of Brinjal and Radish (mg/gdw).

Primary Metabolites	Brinjal				Radish			
	Control water irrigated		Polluted water irrigated		Control water irrigated		Polluted water irrigated	
	Whole plant	Fruit	Whole plant	Fruit	Whole plant	Fruit	Whole plant	Fruit
Ascorbic acid	0.35	0.8	0.9	3.4	1.6	3.90	0.80	3.98
Lipid	62	39.8	61	59.3	34.5	43.2	26.8	39.1
Protein	35.6	30.1	38	12.6	49.9	18	35	35.9
Starch	9.8	9.6	4.9	10.1	6.9	12.5	6.8	12.2
Total Soluble Sugar (TSS) Carbohydrates	29.8	34.5	22	31	19.4	30	18	32.2

Table 2
Quantitative analysis of Pigments and Nucleic acids isolated from control and polluted water irrigated plants of Brinjal and Radish

Primary Metabolites	Brinjal		Radish	
	Control water	Polluted water	Control water	Polluted water
Chlorophyll a (mg/g)	0.9864	0.6419	0.4319	0.3101
Chlorophyll b (mg/g)	0.4139	0.3107	0.3001	0.1439
Total chlorophyll (mg/g)	1.1500	1.0100	0.7380	0.4379
Carotenoids (mg/g)	0.198	0.132	0.374	0.294
DNA ($\mu\text{g/g}$)	2.98	2.15	3.57	0.96
RNA ($\mu\text{g/g}$)	2.14	2.04	3.10	0.87

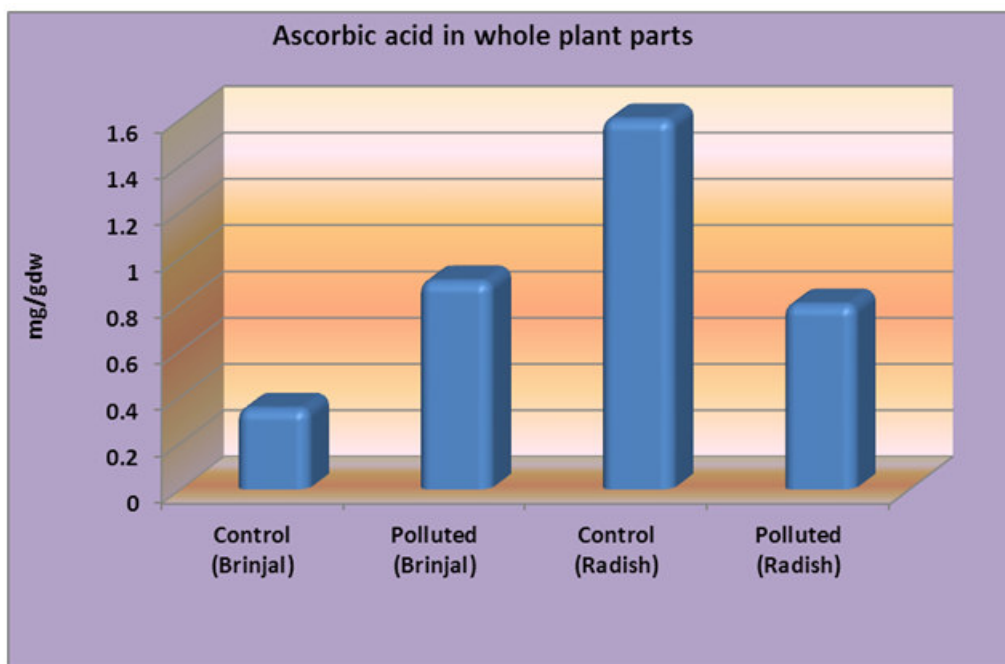


Figure 1
Ascorbic acid in whole plant parts of control and polluted brinjal and radish (SD \pm 0.5) plant parts of control and polluted Brinjal and Radish

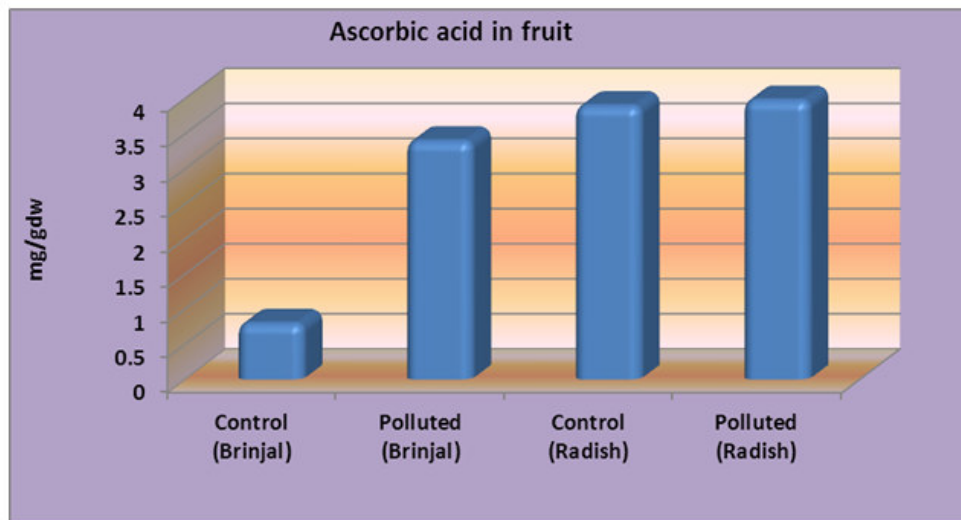


Figure 2
Ascorbic acid in fruits of control and polluted Brinjal and Radish (SD±0.5)

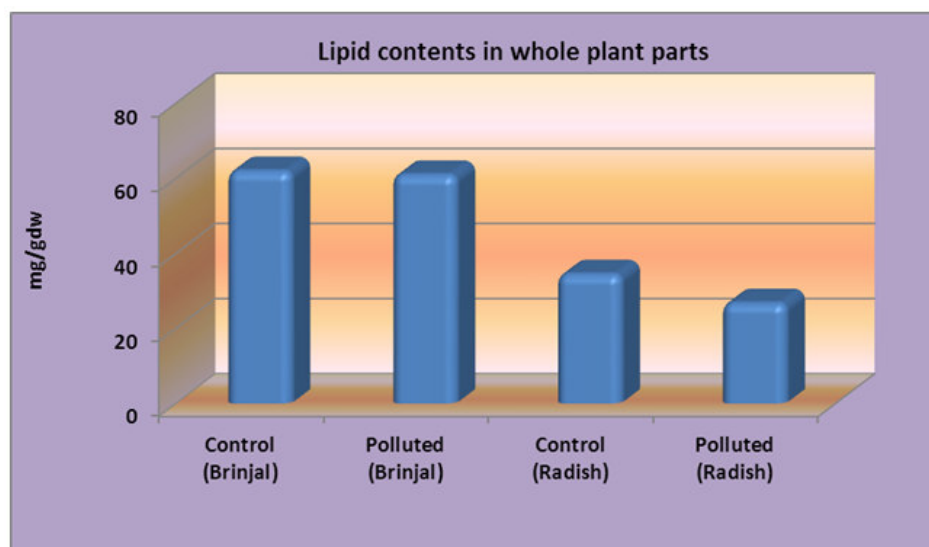


Figure 3
Lipid content in whole plant parts of control and polluted Brinjal and Radish (SD±0.5)

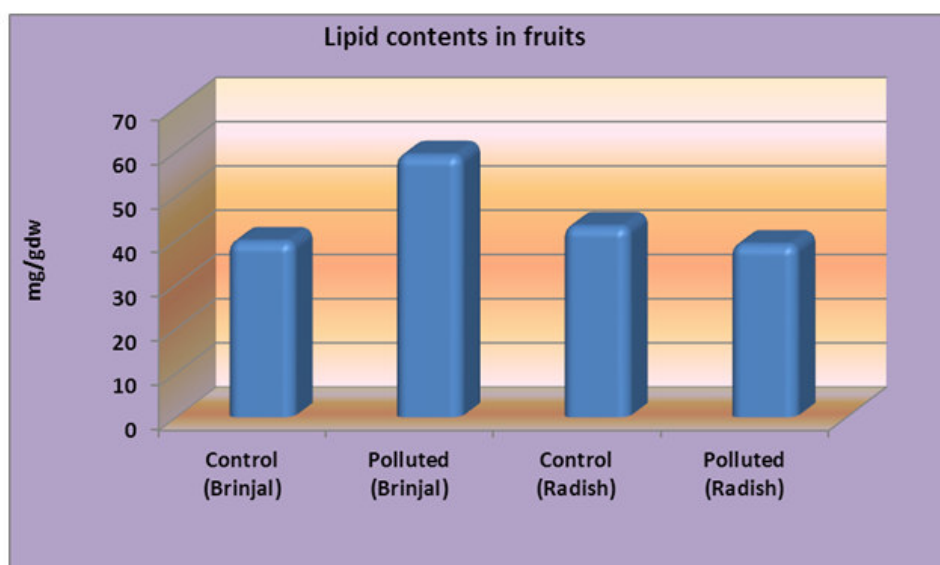


Figure 4
Lipid content in fruits of control and polluted Brinjal and Radish (SD±0.5)

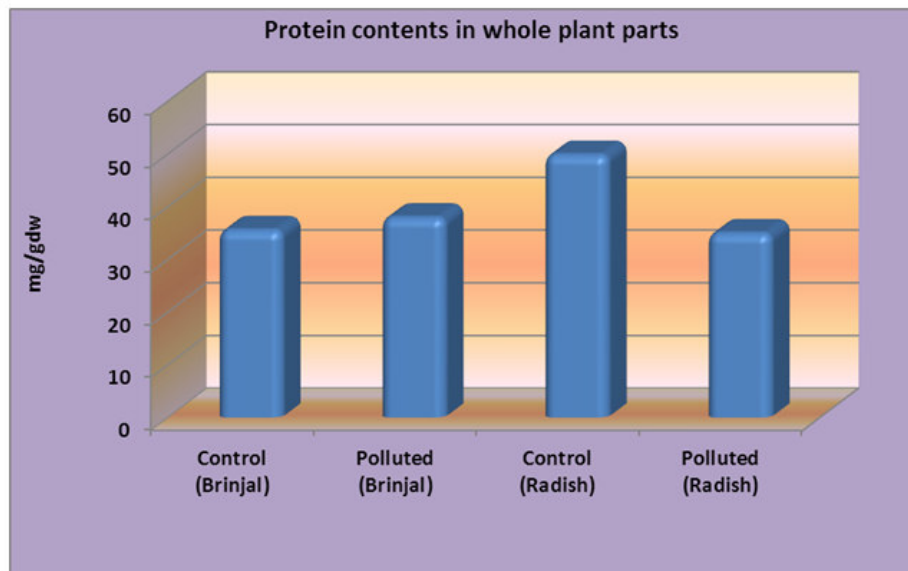


Figure 5

Protein content in whole plant parts of control and polluted Brinjal and Radish (SD±0.5)

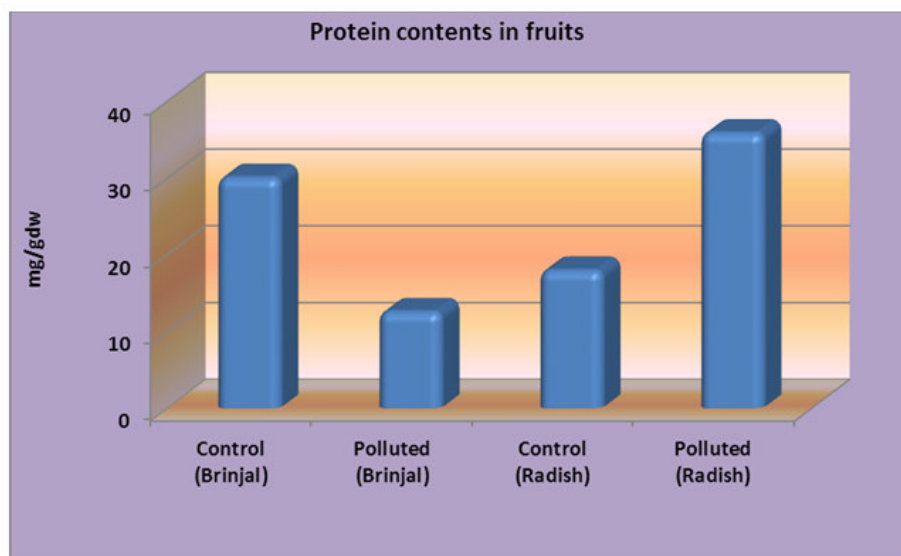


Figure 6

Protein content in fruits of control and polluted Brinjal and Radish (SD±0.5)

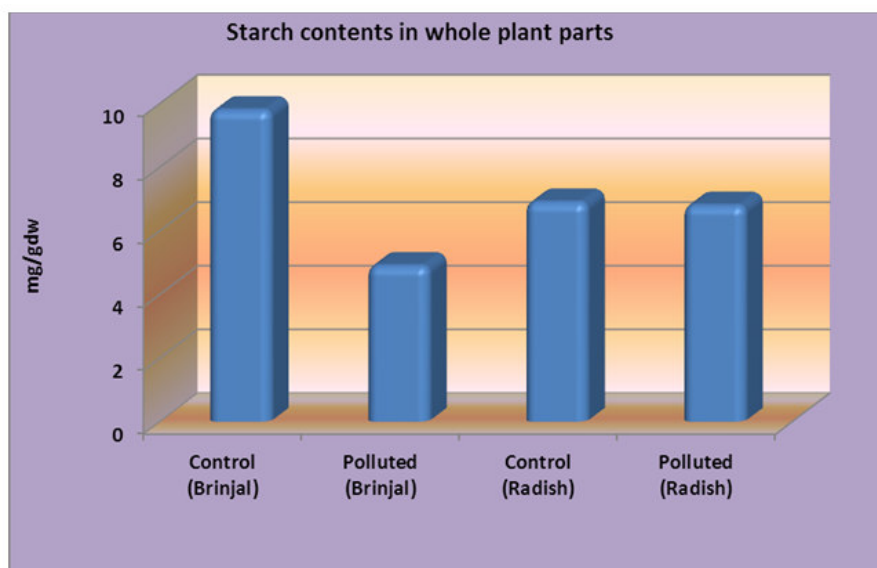


Figure 7

Starch content in whole plant parts of control and polluted Brinjal and Radish (SD±0.5)

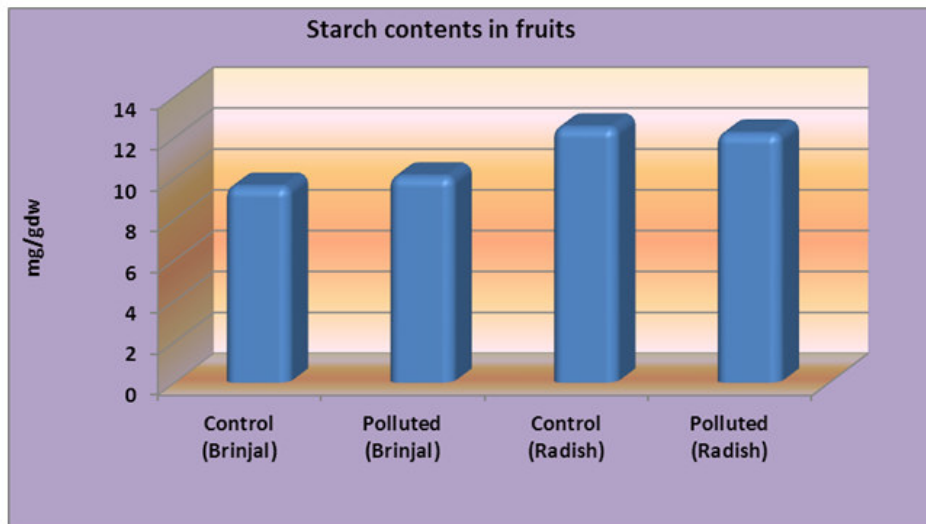


Figure 8
Starch content in fruits of control and polluted Brinjal and Radish (SD±0.5)

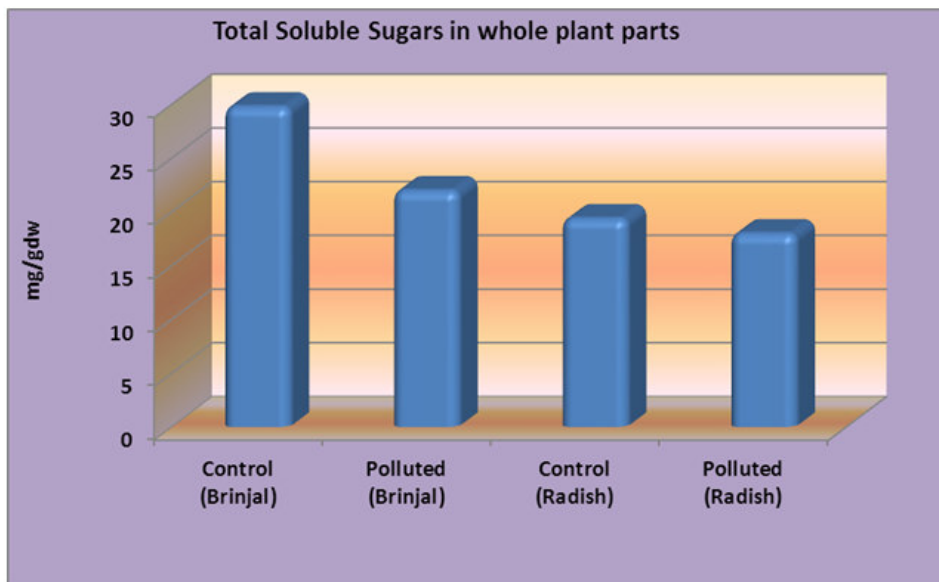


Figure 9
Total soluble sugars in whole plant parts of control and polluted Brinjal and Radish (SD±0.5)

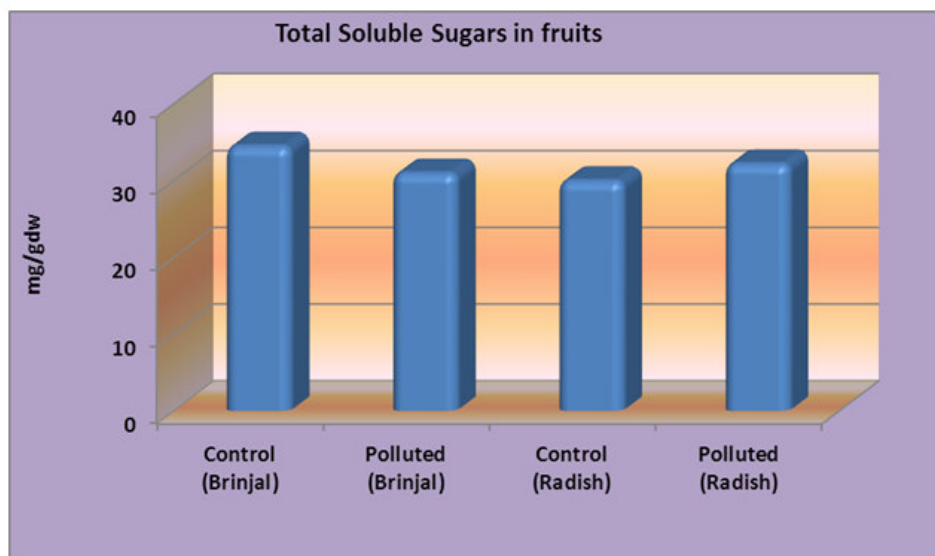


Figure 10
Total soluble sugars in whole plant parts and fruits of control and polluted Brinjal and Radish (SD±0.5)

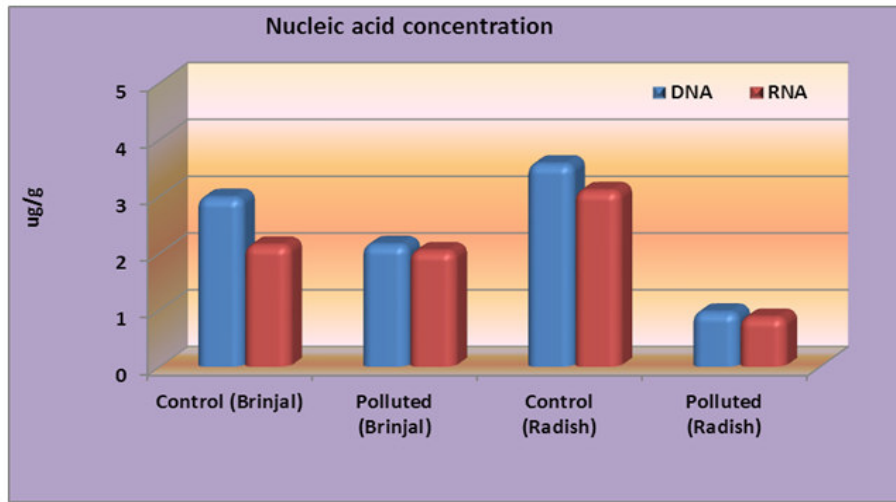


Figure 11
Nucleic acids concentration in control and polluted Brinjal and Radish (SD±0.5)

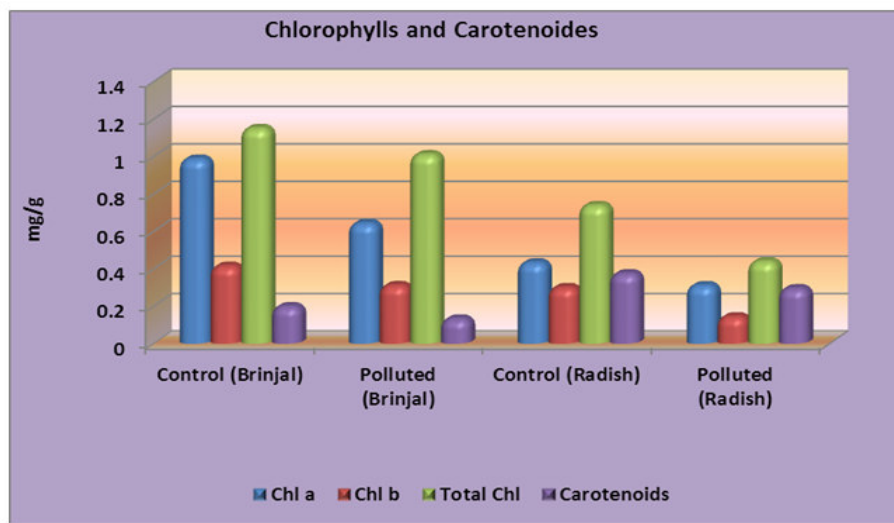


Figure 12
Chlorophylls and carotenoids in control and polluted Brinjal and Radish (SD±0.5)

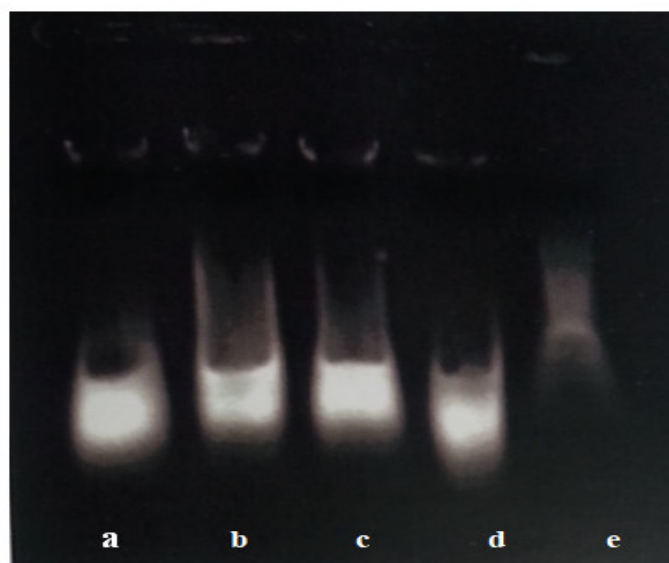


Figure 13
Genomic DNA before purification (first four samples isolated from control water irrigated radish (a), polluted water irrigated radish (b), control water irrigated brinjal (c), polluted water irrigated brinjal (d) & (e) is replica of (d)).

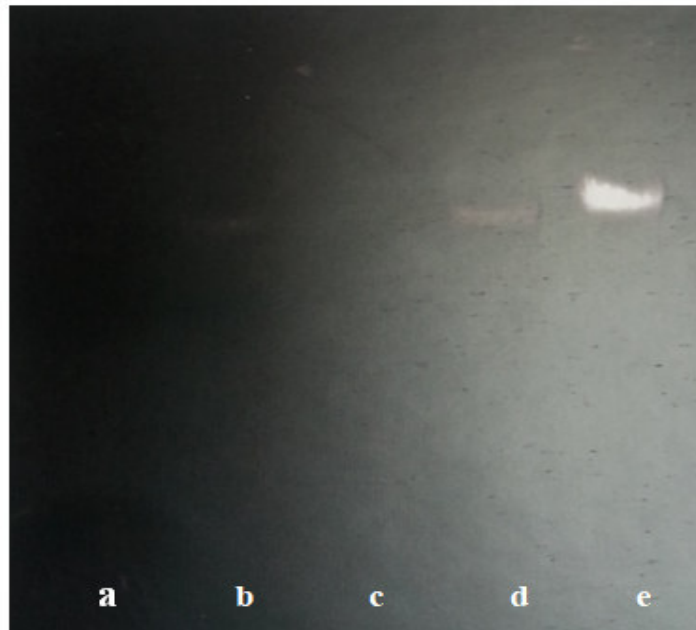


Figure 14

Genomic DNA after purification (Sample a used as a marker: Sample b & c RNase based purification of polluted water irrigated radish and brinjal and d & e: RNase based purification of control water irrigated radish and brinjal).

DISCUSSION

Ascorbic acid (Vitamin C), an essential dietary requirement, exhibits an important role in growth differentiation and metabolism of the plants²⁰. Brinjal (whole plant parts and fruits) grown in polluted water sites contained relatively higher levels of ascorbic acid as compared to control brinjal (whole plant parts and fruits). But the concentration of ascorbic acid was found approximately equal in fruits of radish plants grown in polluted water sites. There was a twofold reduction in the concentration of ascorbic acid in whole plant parts of radish grown in both control and polluted water sites. The lipid content was decreased in the whole plant parts of brinjal grown in polluted water sites than the controls. In polluted water sites fruits contained relatively higher levels of lipid as compared to control ones. There is a reduction in the lipid contents in radish (whole plant parts and fruits) grown in polluted water sites in the comparison to controls. Protein content was higher in the whole plant parts of brinjal grown in polluted water sites as compared to controls. Reverse order is seen in protein content found in the fruits of brinjal. In radish, the whole plant parts of radish plants grown in polluted water sites showed lower proteins as compared to control ones. Radish fruits contained increased levels of proteins in plants grown in polluted water in the comparison to control ones. The starch content in whole plant parts of brinjal and radishes were decreased in

polluted water sites as compared to controls ones. But fruits of brinjal contained higher level of starch in plants grown in polluted water in comparison to control ones. In radish fruits the starch concentration remains almost same. Lower levels of total soluble sugar contents were seen in the whole plant parts and fruits of brinjal grown in polluted water as compared to control ones. While in radish higher quantities of total soluble sugars was found in the whole plant parts of radish plants grown in polluted water as compared to controls. In brinjal fruits the TSS concentration was lesser in polluted sites as compared to controls. No major variation was observed in the total soluble sugar contents in the radish fruits of control and polluted sites. In brinjal and radish, total chlorophyll and carotenoids content were decreased in polluted plants grown in polluted sites as compared to controls²¹. The effects of fertilizer factory effluent on corn and rice and found that higher concentration of effluent caused deleterious effects on the photosynthetic pigments of both test crops. The data presented here seem to agree with this observations.²² The evaluation of photosynthetic stress acts as an index of pollution due to dye industries. Reflection of a significant impact due to this effluent could be seen in chlorophyll content and net photosynthesis, which resulted in drastic reduction in assimilation number from 69.1 to 0.0 for the effluent concentration range from 0.0 to 25%.²³ The impact of Cd toxicity was investigated on pigment content in mungbean seedlings. Chlorophyll-a, chlorophyll-b, total

chlorophyll, and chlorophyll a/b ratio were increased and decreased thereafter with an increase in the concentration of Cd²⁺. Earlier the effect of increased concentrations of cobalt (Co) (0, 50, 100 and 200 mg kg⁻¹) and treatment with sewage sludge was investigated on the chlorophyll pigments and carotenoids of brinjal plants²⁴.

CONCLUSION

Whole plant parts and fruits of brinjal plants grown in polluted water showed higher levels of ascorbic acid as compared to controls. In radish values of ascorbic acid were lower in whole plant parts and higher in fruits in plants grown at polluted sites as compared to control ones. The lipid content was lower in the whole plant parts of brinjal and radish plants grown in polluted sites as compared to control ones. Protein content was increased in the whole plant parts of brinjal grown in polluted sites as compared to controls. These were lesser in the fruits of brinjal. In radish, lesser protein contents were recorded in the whole plant parts of plants grown in polluted sites as compared to control ones. Fruits contained higher levels of proteins in comparison to control. The starch content in fruits of radish and whole plant parts of brinjals and radish were lesser in plants grown in polluted sites

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as compared to controls. However fruits of brinjal plants of polluted sites contained higher level of starch in comparison to control. Total soluble sugar contents were found in the fruits of brinjal plants grown in polluted site were lesser as compared to control ones. In polluted radish, their values were higher in fruits of plants grown in polluted sites as compared to controls but whole plant parts contained lesser levels of TSS. In both brinjal and radish, total chlorophyll, carotenoids and RNA and DNA concentrations were lesser in plants grown in polluted sites as compared to controls.

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CONFLICT OF INTEREST

Conflicts of interest declared none.

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