Heavy metal contamination and induction of antioxidants in local food crops of Malda district under waste water irrigation

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Abstract:

Malda is a district of northern West Bengal, India. The district contributes a lion's share with the country's quality production of raw silk yarn and it is a good exporter of best Mango varities with a annual turn over of about Rs. 5.5 crores. To grow vegetables different subdivisions of Malda district utilizes three main types of irrigation facilities.These are RLI : River lifting irrigation , DTWI : Deep tube well irrigation, STWI : Shallow tube well irrigation. Industrial development and increasing urbanization are the two major causes of heavy metal pollution which is turning to a grave threat via these irrigation sources. The industrial effluent and pollutants through its effect via irrigation sources as well as indiscriminate use of ground water for agricultural purpose is a matter of grave concern to the district of Malda. In this study the documentation of different irrigational water sources along the district subdivisions, municipalities, their analysis for physico - chemical parameters as well as heavy metals were performed. The percolation of heavy metals through irrigation water in the daily available vegetables in the market were selected on presumption and analysed for heavy metal occurrence. The concentrations are awaiting to be concerned specially under RLI as well as the As (Arsenic) concentration due to indiscriminate use of ground water through Shallow tube well. Wastewater in different irrigation sources along the Malda district increased phenolic substances in the local Vegetables and crops which ultimately enhanced the level of antioxidant (heavy metal stress marker , enzyme assays like catalase and peroxidase) in these selected plant species. The effect of heavy metals was found inhibitory in pollen tube germination and pollen tube length in waste water treated selected food crops.. Still this observation may not reduce the risk of pollution and the danger of contamination of local vegetables by heavy metals.

Key words: Heavy metals , antioxidant.

Introduction :

Malda (3733 Sq Km, population 32,90,000) is a district of northern West Bengal , India. The district comprises 2 subdivisions: 1. Chanchal (six community development blocks: Chanchal–I, Chanchal–II, Ratua–I, Ratua–II, Harishchandrapur–I, Harishchandrapur–II) and 2. Malda Sadar (nine community development blocks: English Bazar, Gazole, Habibpur, Kaliachak–I, Kaliachak–II, Kaliachak–III, Manickchak , Old Maldah, Bamangola)**.** English Bazar is the district headquarter. Malda occupies an important place in the map of the State for the production of raw-silk yarn and mango which are the two important aspects of Malda's economy. A good number of crops like rice , wheat , pulses and various vegetables are also cultivated and sold in local markets for daily consumption. The total cultivable area of Malda district is 2853 sq.km. 34.2% of the cultivated area is irrigated by the ground water. 8.5% is irrigated by surface water. 19.9% ground water is replenished from average annual rain fall. . A 30% increase in urban and rural population was recorded in Malda district itself (**District Agri - Irrigation Board, Malda. 2010 – 2011**). The maximum urban municipalities lack proper drainage systems and escape the municipal wastes to rivers, ponds or other water bodies. Irony is that in many places of this district **River lifting irrigation (RLI)** , **Deep tube well irrigation (DTWI)** or **Shallow tube well irrigation** (**STWI**) or **Water from other means** are just adjacent to these drain outlets. So the chances of pollution is a matter of grave concern. Groundwater of many areas of this district is severely contaminated with heavy metals specially in Malda Sadar subdivisions. So, there is every possibility of accumulation of contaminants which may migrate through the irrigation system in the cultivated lands adjacent to these municipalities. Sewage and industrial waste water is commonly used for irrigating agricultural fields in developing countries including India (Sharma et al., 2007; Mishra et al., 2011; Nath et al., 2009; Nagajyothi et al., 2010). Accumulation of toxic heavy metals leads to stress conditions in the plant system by interfering with the metabolic activities and physiological functioning of the plants. Heavy metals are known to cause membrane damage, structural disorganization of organelles, impairment in the physiological functioning of the plants and ultimately growth retardation (Kimbrough et al , 1999 , Chien and Kao , 2000). Heavy metals stimulate the formation of reactive oxygen species (ROS) such as superoxide radicals ($O_2{}^{o}$), hydroxyl radicals (OH^{o}) and hydrogen peroxide (H_2O_2) either by transferring electron involving metal cations or by inhibiting the metabolic reactions controlled by metals (Verma and Dubey, 2001). In order to survive under the stress condition, plants have enzymatic and non enzymatic antioxidants to scavenge free radicals (RS^{o}, H_2O_2) and reactive oxygen species (O^- , $O_2{}^{o}$, OHÚ). Measurement of antioxidants as stress markers is an important aspect for assessing the stress responses in plant system (Gratao et al , 2005). Though urban population increased considerably 240000 to 320950 within 2001 to 2011 and the demand for irrigation water from local water sources (District Agri - Irrigation Board, Malda. 2010 – 2011)

Until 1981 the sewage system of Malda district was not adequate and mostly unplanned. In most areas the local drains escape into nearby rivers or pond like aquesource. In English bazaar adjacent areas according to the present drainage system there are 8 outlet points which are the sights with maximum pollution. The outlets are as follows:

1. Ghorapir trucks turn to Laxmipore drainage 2. Gayeshpur Ghat. 3. Mahananda Setu, Bansh Bari, Kothabari 4. Phulbari Ghat 5. Sashan Ghat, North Balurchar 6. Mission Ghat 7. Irrigation Ghat 8. Maheshpur includes one big drain called Naka drain opens to Phulbari drainage. It was observed that vegetables grown in local areas are also under irrigation of polluted water. The condition so far is not serious but still demands attention. We have analysed the effluent water of municipal drainage which are directly coming into the river bed and tried to correlate with the phenolic content, as well as the antioxidant level by percentage inhibition of DPPH in selected vegetables and crops. A slow but definite progress in the contamination of heavy metals was visualized in local vegetables. **Table 1**.

In this paper we investigated the quality of soil and water from different blocks of subdivisions and the collection was made at random basis. The soil was collected within 50 meters of irrigation source from 6 inches and 12 inches depth and the water collected from ponds, deep tube well , shallow tube well and river lifting irrigation source of Old Malda , Kalindi, Manick Chowk, Ratua I and II, Behula, Habibpur, Iho , Bulbuli, Sahapur, English Bazaar municipality, Sahdullapur and Chanchal. The soil and water were analysed for the physico chemical parameters as well as for the heavy metals specially Cd, Pb, Cr, Ni and As. The vegetables were collected from local market in the adjoining areas of soil and water collection areas. In English Bazaar municipality area the vegetables were collected from Sadar Ghat market, Makdumpur market, Netaji market and Chittaranjan market. In this study the river taken into consideration are Mora Bhagirathi, Behula , Tangan, Kalindi and Mahananda. Among them the Kalindi , Behula adjacent to Old Malda municipality and Mahananda in the English Bazar Municipality exhibit serious concern in terms of contaminated irrigation and subsequently its effect on vegetable and crop cultivation. Heavy metal concentration (mg/kg dry weight) in vegetables grown in waste-water irrigated agricultural lands were estimated. Higher bioavailability of heavy metals in wastewater irrigated sites may have reduced the nutrient availability to plants that may be the cause for not showing significant increments in biomass of these plants as compared to the plants grown at ground water irrigated sites.

Materials and methods

In this study, we investigated the concentrations of Pb, Zn, Cd, Cr, Cu , As and Ni in vegetables grown in the agricultural land of Malda area having long term uses of waste water for irrigation. The levels of contamination were compared with the Indian standard guidelines to assess the potential hazards of heavy metals to public health.

The freshly harvested mature vegetables were brought to the laboratory. The vegetables Cabbage, Spinach, Pea leaves, Gram leaves, Turnip, *Chenopodium* leaves, Ladies Finger, Bottle gourd , Papaya, Tomato, Rice grains, Linseed, Cauliflower, Mango, Mustard, *Cucurbita*, Spinach, Sugarcane, Pudina, Cucumber, Brinjal and *Citrus* (The English names retained for easy identification) were collected from local market in the adjoining areas of soil and water collection areas. The vegetables were collected from markets and washed primarily with running tap water, followed by three consecutive washings with distilled water to remove the soil particles. Samples were cut into small pieces and dried in oven at 70 degree Celcius for 48 h and then ground to powder.

0.5 g each of vegetable samples were digested (wet acid digestion) with concentrated HNO_3, H_2SO_4 and $HClO_4$ (5:1:1) at 80 degree Celcius (Allen et al. 1986) until the solution became transparent. The digested samples of vegetables were filtered through the Whatman No.42 filter paper and the filtrates were diluted to 50 mL with distilled water. All reagents used were Merck, analytical grade (AR) including Standard Stock Solutions of known concentrations of different heavy metals. Heavy metal concentrations of vegetable samples were estimated by Atomic Absorption Spectrometer (Perkin Elmeyer Analyst 400). Blank samples were analyzed after seven samples. Concentrations were calculated on a dry weight basis. All analyses were replicated three times. The accuracy and precision of metal analysis were checked against NIST-SRM, 1570 for every heavy metal. The results were found within ± 2% of certified values. To assess the contamination level of heavy metals, mean, median, minimum, maximum and standard deviation of wastewater, soil and vegetable samples were performed by using Microsoft Excel (Version 2000).

Extraction and determination of methanolic extractive value

10 g tissue of each vegetables were crushed in 40 ml of methanol water (4:1) under soxhlet apparatus for 8 hours and used for several tests.

DPPH based free radical scavenging activity

The free radical scavenging activities of methanolic extract of different vegetables were assayed using a stable DPPH following standard method of Blois , 1958. The reaction mixture contained 1.8 ml of 0.1 mM DPPH and 0.2 ml of each extract (0.5 – 2.0) of vegetables methanol extracts. A control set was prepared without sample extracts. The reaction mixture was allowed to incubate for 5 min at room temperature in the dark and scavenzing activity were quantified by decolorization at 515 nm. Percentage of free radical scavenging activity was expressed as percent inhibition from the given formula :

% inhibition of DPPH radical = Abs of control - Abs of sample / Abs of control x 100

Smith's statistical package (Version 2.5) was used for determining the IC_{50} values of antioxidants and their standard error of estimates (SEE).

Estimation of total phenol content

Total phenolic compounds of plant extracts were determined by Folin-Ciocalteu method (Chandler and Dodds, 1993). For the preparation of the calibration curve, 1 ml aliquot of 0.025, 0.05, 0.075, 0.1, 0.2 and 0.3 mg/ml Methanolic Gallic acid solution was mixed with 5 ml of Folin-Ciocalteu reagent (10 times diluted) and 4 ml sodium carbonate (75 g/L). The tubes were vortexed and allowed to stand for 30 min at 40°C for colour development .The absorbance at 765 nm was measured after 1hour at 20ºC and the calibration curve was drawn. 1ml plant extracts of various concentration was mixed to the same reagent and the mixture was incubated for one hour in room temperature.

Results and Discussion

Table 1 shows the distribution of three irrigation types in number in different blocks of Malda district. The soil test report **(Table 2)** of different survey areas in Malda included Ghora pir pond, Laxmipore bill adjoining area, Kalindi, Milky Ghat river bed, Nurpur agricultural field , Gayeshpur Mahananda ghat, Tangan river bed , Habibpur, Behula river bed, Narayanpur, Old Malda, Mahananda River bed, Mara Bhagirathi , Sahadullahpur river bed**.** Generally phosphate level was high in 0 - 6 inches soil layer but in many areas and it is beyond safe limit. Potassium content was below the safe limit in most of the areas. Concentrations of heavy metals **Pb , Zn, Cd** , **Cr, Cu, Ni and As** in soils of studied areas (**Table 3)** showed content within safe limit. Only Cd and Cr were found at the risk concentrations. The following parameters like total dissolved solid, total hardness, As content, Fluoride content, content of Fe (expressed in ppm) and pH were estimated from waste water effluent in rivers, deep tube well water, shallow water and pond of the studied areas**.** The presence of As was minimum and still it is not in concerning state **(Table 4**). **Table 5** showed heavy metal concentrations (mg/L) in wastewater used for irirrigation in peri-urban regions of Malda district. In **Ghorapir pond** water Cd concentration was high (above the safe limit) and As content also was in considerable concentration. **Laxmipore bill** area and **Tangon river** exhibited high concentrations of Cr. **Kalindi river along side Nurpur** showed high concentrations of Cd. **Gayeshpurghat** , **Behula river** , **Old Malda, Sahapur bridge Mahananda**. **Marabagirathi river and Mahananda river** noticed high concentrations of Pb and border line concentration of As. **Table 6** concluded that in **Cauli flower, Papaya, *Cucurbita*, Cucumber and Gram fruit** the presence of Pb, Zn and Cd was high in concentration in comparison to other metals. In **Pudina and Spinach** also Ni and As concentration remained high. **Raddish** and **cabbage** concentrated Pb and As in a high concentration. The concentration of Zn and Cd was high in **Pea**. In **Turnip** however the concentrations of Zn , Cu and As were high. In **Ladies finger and** tomato the concentration of As was maximum to the level. The **Bottle gourd** , **Mustard and Tomato** Pb, Zn, Cd and Cu were above the safe limit. In **linseed** Cd was high whereas in **rice** Zn , Cd and As were maximum. **Brinjal** was prone to Zn, Cd and Ni. However, it was observed that the species studied so far were all sensitive to As accumulation. The level of antioxidant expressed by DPPH scavenging assay, as revealed from their lower IC_{50} (mg/ml) values in different vegetables collected from market **(Table 7).** Total phenol content was also high in vegetables **(Table 8)** **(Bhattacharyya et al. 2014**. The stress effect of heavy metals is, however, supported by the increase in the level of antioxidants **(Mandal et al. 2010).**

Table 1 : Sources of Irrigation in different blocks of Malda district.

Blocks	Total RLI	Total DTW	Total STW	Others pond,well etc
Harischandra pur I	14	29	3112	25
Harischandrapur II	42	10	4504	12
Chanchal I	26	21	2158	36
Chanchal II	33	32	2233	46
Ratua I	37	37	2661	16
Ratua II	67	77	1440	55
Gazole	51	77	4041	65
Bamangola	36	_	1878	10
Habibpur	56	20	1832	99
Old Malda	51	56	1185	24
English Bazar	25	47	1075	34
Manickchowk	27	17	2425	10
Kaliachowk I	--	13	1327	5
Kaliachowk II	11	24	796	5
Kaliachowk III	3	38	2703	--

(Ref : District Agri - Irrigation Board, Malda. 2010 - 2011)

Conclusion

Table 2 : The soil test report of different survey area in Malda district

Locality	Soil layer/ inches	pH	EC/ds/m	Org.C.%	P kg/ha	K kg/Ha
Ghora pir	0-6	8.1	0.27	0.47	184	147
	6-12	8.3	0.25	0.27	40	
Laxmipore	0-6	7.8	0.32	1.21	164	304
	6-12	7.6	0.33	0.85	148	362
Kalindi , Milky Ghat	0-6	8.1	0.43	0.31	70	90
	6-12	8.2	0.18	0.27	33	67
Nurpur	0-6	8.3	0.19	0.20	128	80
	6-12	8.1	0.17	0.23	104	112
Gayeshpur	0-6	8.1	0.22	0.05	32	74
	6-12	8.3	0.16	0.01	122	64
Tangan	0-6	8.0	0.20	0.75	100	-
Habibpur	6-12	8.2	0.24	0.70	108	-
Behula	0-6	7.6	0.21	0.46	52	-
Narayanpur	6-12	7.5	0.33	0.24	128	-
Old Malda	0-6	7.2	0.14	0.16	92	-
	6-12	7.6	0.19	0.19	70	-
Mahananda	0-6	7.8	0.24	0.10	100	-
River	6-12	8.0	0.19	0.17	60	-
Mara	0-6	8.3	0.65	0.45	28	298
Bhagirathi	6-12	8.1	0.39	0.45	24	230
Safe Limit		6.6 - 7.5	< 1	0.50 – 0.75	> 90	> 350

Table 3. Concentrations of heavy metals in wastewater- irrigated soil (mg/kg dry soil) in Malda district in India

	Pb	Zn	Cd	Cr	Cu	Ni	As
Minimum	99.30	182.00	22.20	118.05	22.00	44.72	0.001
Maximum	168.30	285.00	51.00	190.40	166.50	133.80	2.05
Safe limit	250– 500	300–600	3–6	--------	135–270	75–150	1 - 40

Table 4 : River and Deep tube well water analysis

Locality	Total dissolved solid ppm	Total hardness ppm	As ppm	Fluoride ppm	Fe ppm	pH
Ghorapir Pond water	**358**	**450**	**0.005**	**0.621**	**3.2**	**7.18**
Laxmipore Deep tube well	**211**	**370**	**0.001**	**0.848**	**1.90**	**7.24**
Kalindi river	**218**	**410**	**0.025**	**0.001**	**1.0**	**7.36**
Nurpur RLI	**218**	**430**	**0.04**	**0.01**	**0.10**	**7.59**
Gayeshpur Ghat RLI	**192**	**280**	**0.005**	**0.01**	**0.20**	**8.22**
Tangon river RLI	**83**	**60**	**0.05**	**0.058**	**0.50**	**7.30**
Behula river Narayanpur RLI	**288**	**180**	**0.03**	**0.119**	**0.20**	**7.0**
Old Malda RLI	**83**	**80**	**0.001**	**0.001**	**0.70**	**7.4**
Mahananda River RLI	**90**	**110**	**0.01**	**0.01**	**0.50**	**7.5**
Sahapur bridge Mahananda river RLI	**154**	**250**	**0.005**	**0.001**	**0.60**	**7.6**
Marabagirathi River RLI	**211**	**340**	**0.05**	**0.001**	**0.50**	**7.88**

As = Arsenic , Fe = Iron.

Table 5 : Heavy metal concentrations (mg/L) in wastewater used for irirrigation in urban region of Malda district, India.

Sources	Pb	Zn	Cd	Cr	Cu	Ni	As
Ghorapir Pond water	0.26 +/_0.001	0.01 +/_ 0.002	0.12 +/_ 0.05	0.05 +/_ 0.02	0.01 +/_ 0.002	0.01 +/_ 0.002	0.01 +/_ 0.005
Laxmipore Deep tube well	1.26 +/_0.02	0.12 +/_0.003	1.13 +/_0.005	1.85 +/_0.04	0.002 +/_0.003	0.008 +/_ 0.002	0.01 +/_ 0.10
Kalindi river RLI	0.65 +/_0.009	0.009 +/_ 0.05	0.14 +/_0.12	1.98 +/_0.05	0.009 +/_ 0.006	0.002 +/_ 0.15	0.003 +/_0.10
Nurpur RLI	0.98 +/_0.009	0.01 +/_0.01	0.22 +/_0.01	0.03 +/_0.09	0.008 +/_0.12	0.01 +/_0.23	0.02 +/_0.07
Gayeshpur Ghat RLI	1.25 +/_ 0.005	1.0 +/_0.008	1.45 +/_1.90	2.20 +/_0.009	0.10 +/_0.12	0.03 +/_0.002	0.05 +/_0.009
Tangon river RLI	0.55 +/_ 0.001	0.23 +/_0.008	0.12 +/_0.002	0.01 +/_0.009	0.002 +/_0.008	0.02 +/_0.001	0.01 +/_0.001
Behula river Narayanpur RLI	2.25 +/_ 0.09	1.90 +/_1.20	1.15 +/_0.008	0.10 +/_0.006	0.008 +/_0.005	0.05 +/_ 0.06	0.08 +/_0.009
Old Malda RLI	1.98 +/_0.005	1.09 +/_0.12	0.67 +/_0.12	0.12 +/_1.45	0.009 +/_0.009	0.05 +/_0.22	0.07 +/_ 0.11
Mahananda River RLI	2.43 +/_1.13	1.76 +/_ 1.11	0.98 +/_0.56	0.34 +/_ 0.22	0.05 +/_0.11	0.10 +/_ 0.01	0.87 +/_ 0.005
Sahapur bridge Mahananda river RLI	3.89 +/_ 1.13	2.25 +/_ 0.002	1.09 +/_ 0.009	0.89 +/_ 0.008	0.09 +/_0.005	0.12 +/_ 0.12	0.23 +/_ 0.004
Marabagirathi River RLI	0.98 +/_ 0.005	0.45 +/_ 0.001	1.90 +/_ 0.001	0.45 +/_ 0.005	0.05 +/_0.001	0.02 +/_ 0.008	0.008 +/_0.005
SAFE LIMIT	**0.5**	**2.00**	**0.01**	**0.1**	**0.2**	**0.2**	**0.05**

Table 6. Heavy metal concentration (mg/kg dry weight) in vegetables grown in waste-water irrigated agricultural land in Malda district, West Bengal. (Collected at a random basis from different local markets of areas where from samples of water and soils were made).

Materials	Pb	Zn	Cd	Cr	Cu	Ni	As
Cauliflower	**3.04**	**96.48**	**3.80**	**20.83**	**15.66**	**1.28**	**0.01**
Spinach	**4.79**	**54.21**	**4.58**	**16.30**	**24.49**	**0.22**	**0.002**
Pudina	**2.59**	**39.01**	**1.37**	**17.82**	**26.25**	**3.80**	**0.01**
Radish	**5.63**	**39.05**	**1.79**	**18.02**	**28.08**	**2.70**	**0.20**
Cabbage	**2.12**	**13.20**	**1.05**	**16.23**	**25.00**	**0.03**	**0.01**
Pea leaf	**1.04**	**87.05**	**2.05**	**10.02**	**25.36**	**1.03**	**0.001**
Gram leaf	**3.02**	**52.02**	**1.02**	**14.02**	**37.02**	**0.22**	**0.02**
Turnip	**2.01**	**56.02**	**1.00**	**15.00**	**22.02**	**2.02**	**0.015**
Ladies Finger	**2.02**	**10.00**	**2.00**	**12.00**	**18.02**	**1.02**	**0.045**
Bottle gourd	**4.02**	**77.05**	**2.02**	**6.02**	**35.02**	**1.02**	**0.02**
Papaya	**3.02**	**55.02**	**1.03**	**6.02**	**24.02**	**1.02**	**0.05**
Linseed	**2.25**	**40.21**	**2.23**	**8.36**	**22.02**	**1.02**	**0.002**
Mustard	**3.25**	**88.25**	**3.23**	**10.02**	**10.01**	**1.12**	**0.02**
Cucurbita	**3.46**	**65.23**	**2.36**	**8.01**	**14.22**	**1.14**	**0.03**
Rice	**2.22**	**69.31**	**2.25**	**12.02**	**21.02**	**0.55**	**0.20**
Brinjal	**2.36**	**56.25**	**3.26**	**14.02**	**15.02**	**2.20**	**0.01**
Cucumber	**2.63**	**52.23**	**2.56**	**22.02**	**12.02**	**2.25**	**0.02**
Tomato	**3.58**	**55.45**	**2.85**	**21.02**	**10.02**	**1.25**	**0.02**
Safe limit	**2.5**	**50**	**1.5**	**20**	**30**	**1.5**	**0.05**

Table 7. Values of antioxidant (DPPH scavenging) activity of standard substance obtained for comparison with the values of vegetables presented as IC50 values as % inhibition

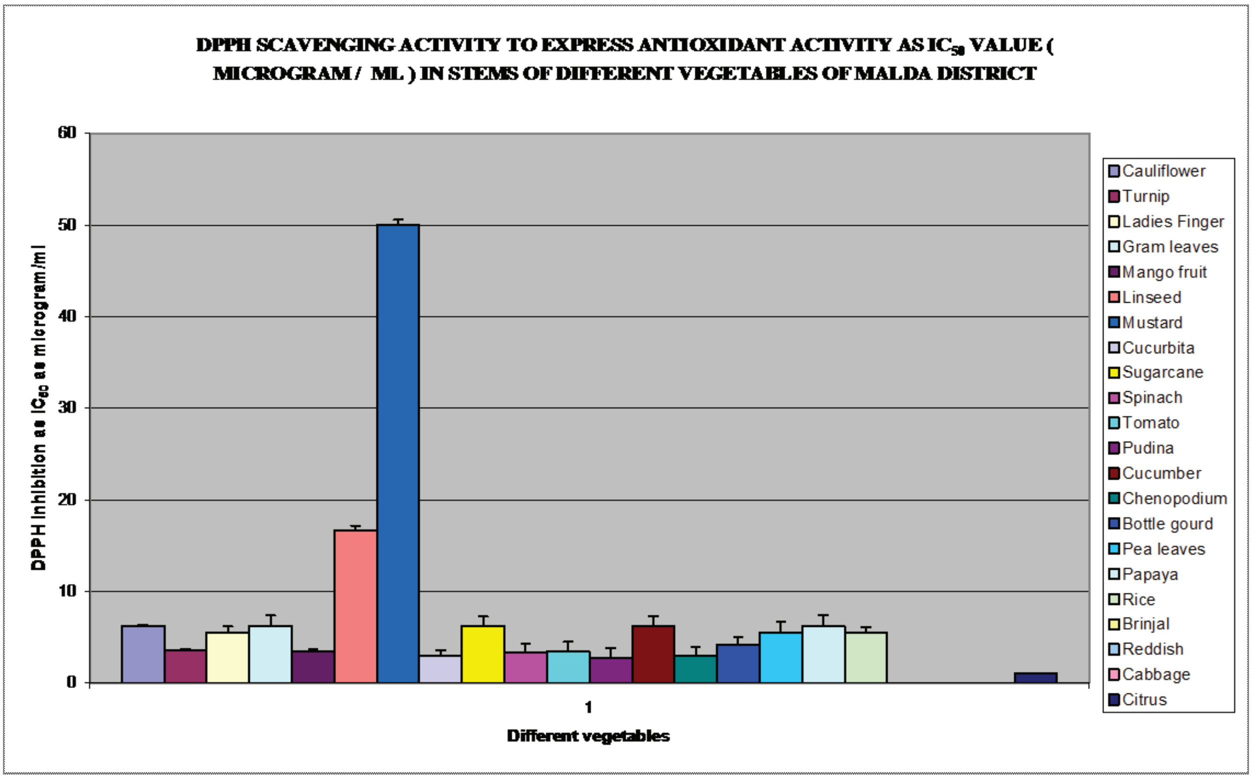
(Mean ± S.E.M a).

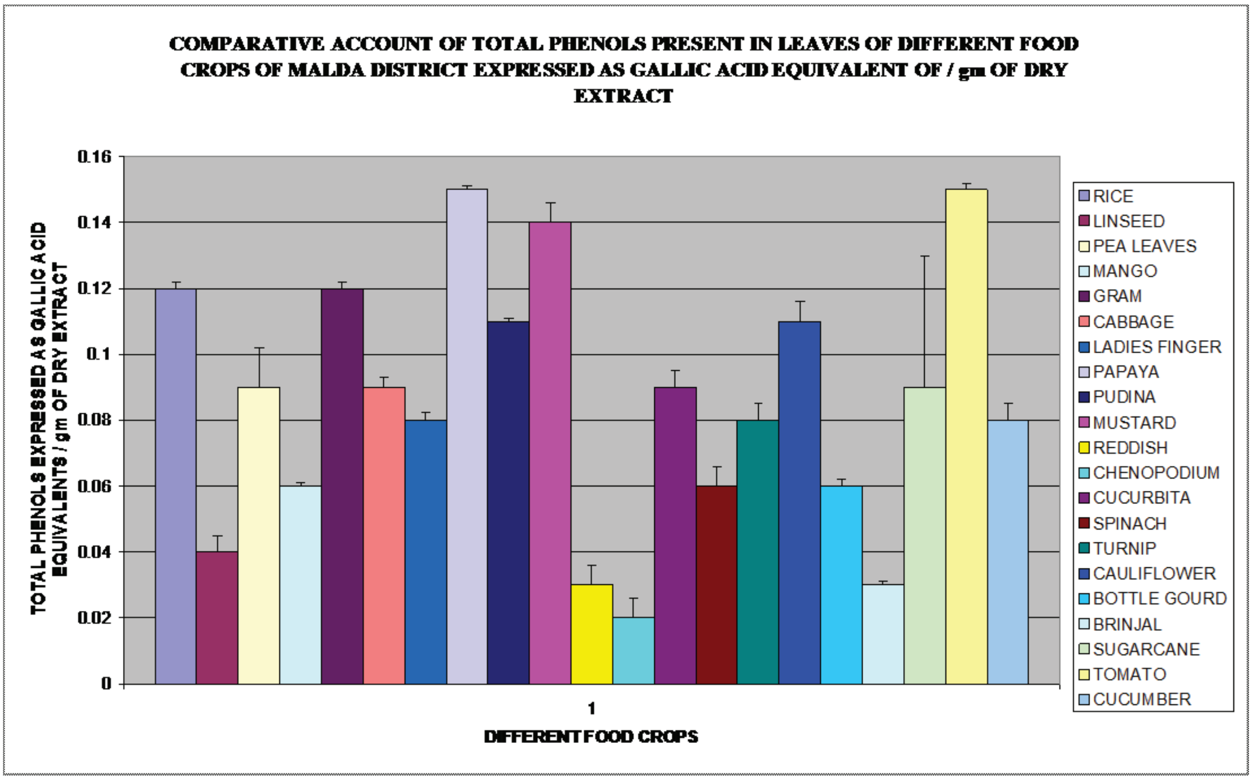
Quercetin : % inhibition = 75.00

Vegetables	**Stem**	**Leaf**	**Root**	**Flower**	**Fruit**
Cauliflower	**40**	**45**	**65**	**50**	**Nil**
Turnip	**75**	**35**	**65**	**40**	**55**
Ladies finger	**45**	**25**	**90**	**75**	**85**
gram	**40**	**15**	**65**	**05**	**65**
Mango	**65**	**50**	**25**	**50**	**40**
Linseed	15	5	55	45	30
mustard	5	0	50	10	15
Cucurbita	85	35	65	55	90
spinach	95	40	85	90	Nil
Sugarcane	75	**Nil**	**Nil**	**Nil**	**Nil**
Tomato	40	35	65	Nil	55 green 45 ripe
Pudina	65	85	95	Nil	Nil
cucumber	90	85	25	25	85
chenopodium	40	45	90	Nil	Nil
Bottle gourd	85	85	35	95	95
Pea	60	90	85	75	85
Papaya	45	50	90	90	Nil
Rice	40	25	45	65	80
Brinjal	45	40	75	50	75
Reddish	**Nil**	50	42	**Nil**	**Nil**
Cabbage	**Nil**	**Nil**	90	**Nil**	**Nil**
Citrus	**Nil**	**Nil**	**Nil**	**Nil**	90

Table 8. Total phenol study in the preselected vegetables from the local market. The content of total phenols in extracts,expressed as gallic acid equivalents (GA) per gram of dry extract, ranged between 8.33 to 169.06 mg GA/ g. (Mean ± S.E.M)a

Vegetables	**Stem**	**Leaf**	**Root**	**Flower**	**Fruit**
Cauliflower	**0.12**	**0.07**	**0.05**	**0.10**	**Nil**
Turnip	**0.11**	**30.08**	**0.06**	**0.01**	
Ladies finger	**0.07**	**0.08**	**0.06**	**0.08**	**0.12**
Gram	**0.12**	**0.15**	**0.08**	**0.10**	**0.20**
Mango	**0.04**	**0.06**	**0.02**	**0.10**	**0.17**
Linseed	0.11	0.05	0.07	0.10	0.12
mustard	0.12	0.08	0.11	0.17	0.20
Cucurbita	0.05	0.09	0.02	0.08	0.15
spinach	0.08	0.05	0.06	0.02	Nil
Sugarcane	0.12	**Nil**	**Nil**	**Nil**	**Nil**
Tomato	0.20	0.15	0.12	0.11	green 0.22 ripe0.25
Pudina	0.20	0.12	0.15	Nil	Nil
cucumber	0.22	0.25	0.04	0.06	0.26
Chenopodium	0.04	0.06	0.12	Nil	Nil
Bottle gourd	0.14	0.14	0.06	0.25	0.25
Pea	0.02	0.22	0.12	0.11	0.11
Papaya	0.01	0.02	0.14	0.14	Nil
Rice	0.02	0.01	0.02	0.05	0.10
Brinjal	0.02	0.02	0.05	0.05	0.06
Reddish	**Nil**	0.05	0.05	**Nil**	**Nil**
Cabbage	**Nil**	**Nil**	0.02	**Nil**	**Nil**
Citrus	**Nil**	**Nil**	**Nil**	**Nil**	0.12


DPPH SCAVENGING ACTIVITY TO EXPRESS ANTIOXIDANT ACTIVITY AS IC50 VALUE (MICROGRAM / ML) IN STEMS OF DIFFERENT VEGETABLES OF MALDA DISTRICT
DPPH inhibition as IC50 as microgram/ml
60
50
40
30
20
10
0
1
Different vegetables
Cauliflower
Turnip
Ladies Finger
Gram leaves
Mango fruit
Linseed
Mustard
Cucurbita
Sugarcane
Spinach
Tomato
Pudina
Cucumber
Chenopodium
Bottle gourd
Pea leaves
Papaya
Rice
Brinjal
Reddish
Cabbage
Citrus


COMPARATIVE ACCOUNT OF TOTAL PHENOLS PRESENT IN LEAVES OF DIFFERENT FOOD CROPS OF MALDA DISTRICT EXPRESSED AS GALLIC ACID EQUIVALENT OF / gm OF DRY EXTRACT
TOTAL PHENOLS EXPRESSED AS GALLIC ACID EQUIVALENTS / gm OF DRY EXTRACT
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1
DIFFERENT FOOD CROPS
RICE
LINSEED
PEA LEAVES
MANGO
GRAM
CABBAGE
LADIES FINGER
PAPAYA
PUDINA
MUSTARD
REDDISH
CHENOPODIUM
CUCURBITA
SPINACH
TURNIP
CAULIFLOWER
BOTTLE GOURD
BRINJAL
SUGARCANE
TOMATO
CUCUMBER

The level of contaminants in different source of irrigation in Malda district , due to waste water mixing and absence of water flow in the river as well as indiscriminate use of ground water sources remained a threat to local vegetables and fruits to be impregnated by heavy metals and their accumulation. The level of heavy metals in river water, and ground water is not so much concerning still in many areas of the District but it may cause serious disturbances if not properly controlled. The constant increasing use of urban utilities provide additional increment to the heavy metal stock in those organic phyto food stuffs. The water from the Behula river, Mahananda Sahapur area, Gayeshpur ghat area showed high presence of Heavy metals. The tube well water from Laxmipur Bill area and pond water in Ghorapir also showed considerable contamination due to heavy population.

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