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Effects of Buriganga and Turag River Water on the Yield and Heavy Metal Contents of Indian Spinach

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Abstract

There are different types of essential nutrients are found in vegetables which are good for human health. But now a days the vegetables which are irrigated with Buriganga and Turag river water may be contaminated with heavy metals because of industrial effluents discharge into the Buriganga and Turag river water. The present study was conducted to investigate the levels of heavy metals like Lead (Pb), Cadmium (Cd), Cupper (Cu), Chromium (Cr), Zinc (Zn), Arsenic (As), Nickel (Ni), and Iron (Fe) in Indian Spinach irrigated with polluted Buriganga and Turag river water. Heavy metals contaminated water and vegetable samples were analyzed by Atomic Absorption Spectrophotometer. The Pb, Cd, Ni, Cr, As, Zn, and Cu contents in Buriganga river water applied in Indian spinach ranged from 0.798-2.06, 0.011-0.60, 0.001-3.87, 0.378-1.25, 0.001-0.610, 6.21-23.24, and 2.01-13.69 µg g^{-1}, respectively and those of Turag river water ranged from 0.023- 0.781, 0.001-0.610, 0.001-0.360, 0.133-0.279, 0.001-0.360, 3.16-8.97, and 0.210-6.47 µg g^{-1}, respectively. The root and shoot length was decreased from 5.3 to 3.2 cm and from 7.2 to 5.5 cm for Buriganga river water applied plant samples. The root and shoot length of Turag river water applied plant samples were decreased from 3.83 to 3.10 cm and 6.93 to 6.18 cm, respectively. The number of leaves was decreased from 7.46 to 5.58 and 8.69 to 5.32 for Buriganga and Turag river water applied plant samples, respectively. The yield of Buriganga and Turag river water applied Indian spinach sample decreased 23.06% and 24.70% from the control plant sample. It is recommended that in spinach plant the concentration of Pd, Zn and Cu crossed the standard limits of FAO and WHO, indicating a potential risk to human body. Awareness should be created among the farmers about the serious consequences of using polluted river water for growing leafy vegetables in city areas.

Key words: Buriganga river, Heavy metal contents, Indian Spinach, Turag river and Yield

Introduction

Bangladesh is a riverine country. Different types of large and small rivers flow on this country. These rivers play an important role to develop in our economic sectors because most of the industries build up on the bank of these rivers. Buriganga and Turag river are the major river around the Dhaka and Gazipur city. Thousands of small and large industries build up on the bank of these two rivers. The increasing urbanization and industrialization of Bangladesh have negative implications for water quality where the industrial effluents directly discharge into the rivers without any consideration of the environment (BCAS, 2000). Now a days for increasing economic growth, rivers are polluted by dumping of untreated huge amount of industrial effluents containing heavy metals like Pd, Cd, Cr, Ni, As, Zn, Cu etc. Moreover household wastes, market wastes, sewage systems, medical wastes, tannery wastes, oil spill from water vehicles are another sources of river water pollutions.

High amount of heavy metal contents were found in the water of Buriganga and Turag river because of improper industrial practices. On the banks of these rivers, people uses this heavy metal contaminated water for irrigation purpose to produces crops. It is a very easy and common practices in our country because of farmers do not have to pay any cost for using river water and it is available everywhere. Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation may not only result in soil contamination, but also affect food quality and safety (Muchuweti *et al.,* 2006). Heavy metals are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops (Mapanda *et al*., 2005). Different types of vitamins and minerals in the leafy vegetables are essential for developing human health. Recently it is issues of concerned that heavy metal contents are found in the leafy vegetables which are irrigated with polluted river waters. Heavy metals are harmful for human and other living organisms because of their non-biodegradable; long time half-lives and capability of accumulate in human health and other living organisms and creating different types of diseases like cancer, heart diseases, skin diseases and so on.

Some previous studies only focused on the physico-chemical properties of Buriganga and Turag river water (Mobin *et al*., 2014, Mokaddes *et al*., 2013). But detailed information on the effects of Buriganga and Turag river water on yield and heavy metal contents in leafy vegetables is limited. This study was conducted to investigate the effects of Buriganga and Turag river water on yield and heavy metal contents in Indian Spinach.

Materials and Methods

Collection and preparation of water sample

Water samples were collected from 30 most polluted areas of Buriganga and Turag river. For irrigation and chemical analysis nearly about 5 L water samples were collected in fresh plastic container from each location. After collecting water samples, few drops Toluene were added to prevent the growth of micro-organisms. Heavy metal analyses were done in the Laboratory of Soil Science Division of Bangladesh Agricultural Research Institute (BARI).

Test crop and pot preparation

Indian Spinach was used as plant materials to investigate the effects of polluted river water from Buriganga and Turag on yield and heavy metal contents. The soil for pot preparation was collected from Bangladesh Institute of Nuclear Agriculture (BINA) and dried separately in a room for few days. The size of pot was 15 cm diameter at the top and 15 cm diameter at the bottom with 10 cm depth. The pot were labeled earlier and filled with 2 kg soil. The seeds were sown at 1st March, 2016 maintaining a uniform distance and covered with soil. After 4 to 5 days of sowing, the seeds were germinated. Water samples from Buriganga and Turag river were applied after proper growth of plants. Three treatments i.e., before use of river water, after use of river water and control (use of distills water) were applied on this study.

Data collection

The plants were harvested after 45 days of sowing of seeds. Plant height (cm), shoot length (cm), root length (cm), no of leaves plant^{-1}, fresh and dry weight of root and shoot (g) were collected with their mean values under each treatment.

Digestion of the vegetable samples

After collection, the samples were washed with distilled water to remove soil particles. The collected plant samples were dried in an oven at 60^{o}C for about 48 hours. Then the samples were grained and sieved for powder samples. Then 0.5g of powdered shoot and root materials were taken separately into 250 mL conical flask and added 10 mL di-acid mixture (HNO_3 : $HClO_4$ = 2:1). Then the flask placed on an electric hot plate for heating at 180-200^{o}C until the solid particles disappeared and white fumes were evolved from the flask. Flask cooled at room temperature, and filtered with whatman No.42 filter paper. This solution was used for the determination of heavy metals Pb, Cr, As, Zn, Cu, Fe, and Ni.

Determination of heavy metal contents in Indian spinach

After completing the digestion procedure, samples were taken for analysis of the heavy metals using SpectrAA-55B atomic absorption spectrophotometer in the laboratory of Soil Science Division of BARI.

Determination of heavy metal contents in Buriganga and Turag river water

Heavy metal contents in Buriganga and Turag river water were determined in laboratory of Soil Science Division, BARI. Data of heavy metal contents were followed from the Nawshin *et al*., 2016.

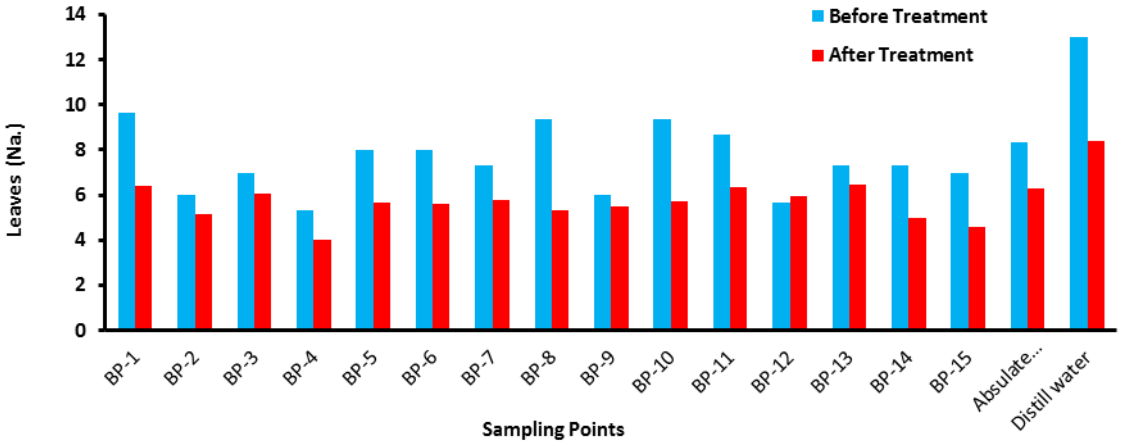
Result and Discussion

Effects of heavy metal contents on Indian spinach were analyzed using the parameters: root and shoot length (cm), root and shoot weight (g), leaf numbers etc.

Effect of heavy metal contents on leaf number

Heavy metal contaminated water of Buriganga and Turag river created bad effect on leaf number of Indian spinach. Before applying Buriganga river water the average leaf no. of plants of 15 pots ranged from 5.3-9.7 with average of 7.46 (Table 1). The average no. of leaf in control of plants was 8.3. After applying treatment the average leaf no. of plants ranged from 4-6.4 with mean value of 5.58.

For Turag river water treatment the leaf no. of plants ranged from 5.7 to 11.7 before applying the treatment with average value was 8.69 (Table 1). After applying the treatment the average leaf no. of plants of 15 pots ranged from 3.9 to 6.7 with mean value of 5.32. Fig. 2 shows that, leaf number of Indian spinach before and after applying the treatment of Buriganga and Turag river water. It was found that before applying treatment, the average leaf numbers was high and after applying treatment the leaf number was reduced because of some leaf were died after applying Buriganga and Turag river water.



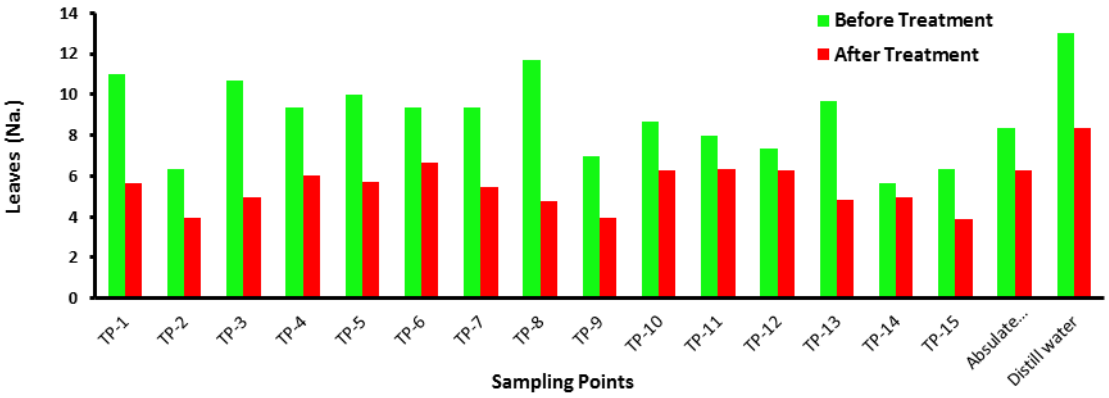


Fig. 1. Leaf number of Indian spinach before and after applying of Buriganga and Turag river water samples, respectively.

Effects of heavy metal contents shoot weight

From the Table 1 it is found that before and after applying treatment of Buriganga river water, total fresh weight of shoots were ranged from 2.85 to 8.65 g (Fig. 3) with an average of 6.20 g and 8.64 to 2.34g with mean of 4.11g, respectively. Before and after applying treatment of Turag river water, total weight of shoot ranged from 3.48 to 8.93 g with an average of 6.26 g and from 2.17 to 6.76 g, with mean value of 4.32g, respectively (Table 1).

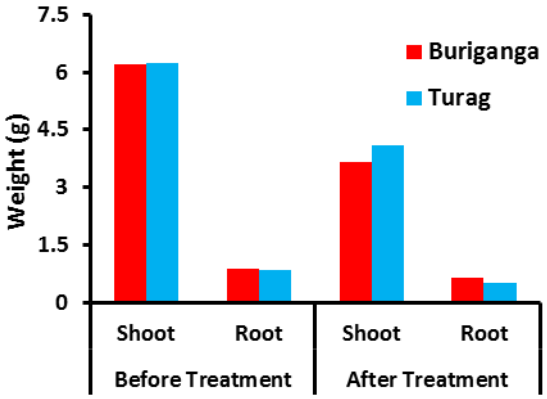


Fig. 2. Average shoot and root weight of Indian spinach before and after treatment.

Effects of heavy metals on root weight

After applying the treatment of Buriganga river water, average weights of roots ranged from 0.17 to 2.46 g with an average of 0.76 g, respectively (Table 1). Average weight of roots before applying treatment ranged from 0.12 to 1.38 g, respectively with an average of 0.63g (Table 1). After applying the treatment of Turag river water, average weights of roots ranged from 0.15 to 1.06 g with an average value of 0.51g.

Accumulations of heavy metal

Under the application of Buriganga river water, the level of Pb in Indian spinach was ranged from 0.798 to 2.06 µg g^{-1} with mean value of 1.276 µg g^{-1}. The permissible limit in plants recommended by FAO/ WHO (1993) is 0.3 µg g^{-1} and SEPA (2005) limit is 9.0 µg g^{-1}. From the (Table 3) it is found that all the Indian spinach samples were below SEPA limit but crossed the FAO limits. The value of Cd ranged from 0.011 to 0.60 µg g^{-1} with mean value of 0.244 µg g^{-1} where the permissible limits of FAO (1993) and SEPA (2005) is 0.02 µg g^{-1}. Here most of the samples exceed the permissible limits. The amount of Ni, Cr and As in plant samples ranged from 0.001 to 3.87 µg g^{-1} with mean value of 0.530 µg g^{-1}, from 0.378 to 1.25 µg g^{-1} with mean value of 0.770 µg g^{-1} and ranged from 0.001 to 0.610 µg g^{-1} with average value of 0.177 µg g^{-1}, respectively which were not exceed the standard limits (Table 3). The concentration of Zn in spinach ranged from 6.21 to 23.24 µg g^{-1} with mean value of 11.90 µg g^{-1} (Table 3) which is closely related to 22.7 µg g^{-1} reported by Zakir *et al*. (2009). Zn value was much higher than the FAO limits but was lower than the SEPA limit (100 µg g^{-1}). The concentration of Cu content ranged from 2.01 to 13.69 µg g^{-1} with average value of 8.80µg g^{-1} (Table 1). According to FAO/WHO, the acceptable limit of Cu for plants is 40 µg g^{-1}.

A change of Indian spinach plant samples was found after applying the collected water samples from Turag river.

The concentration of Pb in plant samples (TP-1 to TP-15) ranged from 0.023 to 0.781 µg g^{-1} with mean value was 0.375 µg g^{-1} (Table 3) which exceeded the standard limits of FAO and SEPA. The average of Cd content in Turag river water applied plants was 0.244 µg g^{-1} and a ranged from 0.011 to 0.60 µg g^{-1} where mean value is similar to the standard of FAO and SEPA limits. From the Table no 3, it is found that the average concentrations of Ni, Cr, and As were 0.273, 0.186 and 0.152 µg g^{-1}, respectively. The concentration of Zn was ranged from 3.16-8.97 µg g^{-1} with average value of 5.61µg g^{-1} which was below the standard limits of FAO and SEPA. The amount of Cu ranged from 0.210 to 6.470 µg g^{-1} with average value of 4.19 µg g^{-1}.

High amount of heavy metal mixed with Buriganga and Turag river water. When this water applied on Indian spinaches the growth and yield reduced due to the accumulation of heavy metal contents in plants bodies and decreased their growth rate. From the Fig. 3 it is

found that the yields of Buriganga river water applied spinach decreased 67.94% compared with distill water applied Indian spinach samples and it is lower than the Turag river water applied plant samples. The yield of Turag river water applied samples decreased 66.30% compared to distill water applied samples.

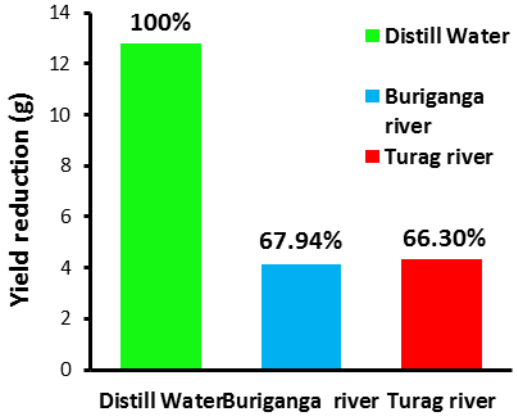


Fig. 3. Average yield reduction of Indian spinach applying Buriganga and Turag river water compared with Distill water.

It is seen that the heavy metal contents in plant was higher than the heavy metal contents of water samples. The probable explanation is plants were irrigated by the river water samples almost twice in a day.

For approximately 45 days until harvest. Some portion of the heavy meal was absorbed by the plant immediate after application and major part was accumulated in the soils which in turn were uptake by the plant during its growth period. This may be the main reason of higher heavy metal content of Indian Spinach than the heavy metal contents of the river water.

Table 1. Average and mean values of yield contributing parameters of Indian spinach

Plant parameters		BP-1 to BP-15		TP-1 to TP-15	
		Before	After	Before	After
Shoot length	Range	7.2-13.7	5.5-11.47	6.1-12.7	6.83-12.17
	Mean	10.23	8.35	9.75	9.12
Root length	Range	5.3-10.1	3.2-7.1	3.1-9.7	3.83-8.6
	Mean	7.51	5.53	7.20	6.16
Leaf number	Range	5.3-9.7	4-6.4	5.7-11.7	3.9-6.7
	Mean	7.46	5.58	8.69	5.32
Shoot weight	Range	2.85-8.65	2.34-8.64	3.48-8.93	2.17-6.76
	Mean	6.20	4.11	6.26	4.32
Root weight	Range	0.35-1.14	0.17-2.46	0.12-1.38	0.15-1.06
	Mean	0.67	0.79	0.63	0.51

Table 2. Heavy metal contents of some water samples of Buriganga and Turag river water.

Heavy metal contents (mg L^{-1})								
River name	Sampling points	Pb	Cd	Ni	Cr	As	Zn	Cu
Buriganga River	BP-1	0.078	0.024	0.015	0.121	0.008	0.191	0.158
	BP-2	0.067	0.011	0.013	0.089	0.000	0.347	0.128
	BP-3	0.058	0.026	0.012	0.101	Trace	0.298	0.188
	BP-4	0.098	0.013	0.003	0.396	0.006	0.379	0.232
	BP-5	0.038	0.009	0.022	0.591	0.005	0.789	0.245
	BP-6	0.054	0.019	0.010	0.456	0.004	0.827	0.198
	BP-7	0.065	0.013	0.013	0.159	Trace	0.745	0.187
	BP-8	0.071	0.021	0.029	0.198	0.004	0.297	0.205
	BP-9	0.073	0.024	0.011	0.137	0.004	0.371	0.148
	BP-10	0.064	0.010	0.012	0.167	0.007	0.541	0.139

	BP-11	0.058	0.007	0.014	0.178	0.009	0.847	0.175
	BP-12	0.081	0.016	1.030	0.092	0.010	0.453	0.194
	BP-13	0.076	0.023	0.011	0.289	Trace	0.361	0.247
	BP-14	0.069	0.014	0.013	0.381	0.002	0.279	0.176
	BP-15	0.065	0.012	0.014	0.196	0.020	0.368	0.223
Range		0.038-0.098	0.007-0.026	0.003-1.03	0.089-0.591	Trace-0.02	0.191-0.847	0.128-0.247
Mean		0.068	0.016	0.081	0.237	0.006	0.473	0.19
Turag River	**TP-1**	0.017	0.150	0.013	0.035	0.002	0.064	0.014
	TP-2	0.011	0.018	0.013	0.014	0.001	0.049	0.006
	TP-3	0.012	0.002	0.014	0.016	0.003	0.104	0.019
	TP-4	0.019	0.014	0.014	0.045	0.001	0.029	0.011
	TP-5	0.001	0.016	0.025	0.017	0.001	0.125	0.008
	TP-6	0.009	0.015	0.013	0.023	0.004	0.071	0.018
	TP-7	0.013	0.013	0.021	0.037	0.003	0.094	0.025
	TP-8	0.006	0.014	0.012	0.043	0.002	0.089	0.006
	TP-9	0.002	0.015	0.014	0.031	0.002	0.043	0.024
	TP-10	0.018	0.015	0.012	0.002	0.001	0.052	0.009
	TP-11	0.011	0.013	0.017	0.041	0.002	0.131	0.017
	TP-12	0.017	0.012	0.011	0.047	0.003	0.064	0.011
	TP-13	0.013	0.013	0.014	0.075	0.001	0.081	0.01
	TP-14	0.016	0.011	0.013	0.068	0.001	0.072	0.007
	TP-15	0.017	0.001	0.012	0.02	0.002	0.063	0.018
Range		0.001-0.019	0.001-0.15	0.011-0.025	0.002-0.075	0.001-0.004	0.029-0.131	0.006-0.025
Mean		0.012	0.021	0.015	0.034	0.002	0.075	0.014

Source: Nawshin *et al*., 2016

Table 3. Heavy metal contents of Indian spinach under the treatment of Buriganga and Turag river water

Heavy metal contents in Indian Spinach (µg g^{-1})								
River name	**Sampling points**	**Pb**	**Cd**	**Ni**	**Cr**	**As**	**Zn**	**Cu**
Buriganga River	**BP-1**	1.64	0.36	0.36	0.798	0.56	8.36	9.14
	BP-2	1.35	0.12	0.21	0.498	0.34	10.94	7.14
	BP-3	1.21	0.49	0.31	0.521	0.00	9.21	8.36
	BP-4	2.06	0.14	0.00	0.891	0.14	11.25	10.57
	BP-5	0.80	0.13	0.48	1.250	0.16	14.52	13.69
	BP-6	0.82	0.24	0.12	1.150	0.00	16.14	6.97
	BP-7	1.01	0.29	0.38	0.824	0.21	6.21	7.74
	BP-8	1.21	0.60	0.56	0.853	0.11	7.24	10.78
	BP-9	0.99	0.57	0.47	0.769	0.13	23.24	2.01
	BP-10	1.09	0.01	0.21	0.378	0.17	8.64	8.76
	BP-11	0.87	0.26	0.01	0.783	0.61	15.27	8.74
	BP-12	1.71	0.24	3.87	0.478	0.00	19.71	6.75
	BP-13	1.55	0.12	0.25	0.876	0.02	8.63	11.89
	BP-14	1.51	0.08	0.31	0.941	0.00	9.87	7.78
	BP-15	1.32	0.01	0.41	0.536	0.19	9.27	11.63
Range		0.798-2.06	0.011-0.60	0.001-3.87	0.378-1.25	0.001-0.610	6.21-23.24	2.01-13.69

Mean		1.276	0.244	0.530	0.770	0.177	11.90	8.80
Turag River	**TP-1**	0.64	0.91	0.34	0.20	0.12	4.67	5.71
	TP-2	0.52	0.12	0.01	0.21	0.01	3.98	4.97
	TP-3	0.61	0.00	0.45	0.17	0.16	6.87	5.23
	TP-4	0.78	0.25	0.21	0.21	0.01	3.16	5.98
	TP-5	0.02	0.27	0.54	0.18	0.13	8.97	4.36
	TP-6	0.19	0.31	0.30	0.17	0.36	5.24	3.98
	TP-7	0.30	0.01	0.51	0.18	0.31	6.68	1.17
	TP-8	0.13	0.27	0.21	0.19	0.25	6.74	6.47
	TP-9	0.22	0.26	0.38	0.28	0.00	4.94	5.74
	TP-10	0.38	0.57	0.00	0.13	0.12	3.45	0.21
	TP-11	0.25	0.37	0.61	0.26	0.24	8.84	4.13
	TP-12	0.36	0.00	0.00	0.18	0.26	4.61	4.26
	TP-13	0.28	0.38	0.26	0.13	0.24	5.93	1.49
	TP-14	0.31	0.02	0.27	0.16	0.07	5.49	5.97
	TP-15	0.36	0.04	0.00	0.15	0.01	4.51	3.17
Range		0.023-0.781	0.001-0.910	0.001-0.610	0.133-0.279	0.001-0.360	3.16-8.97	0.210-6.470
Mean		0.357	0.252	0.273	0.186	0.152	5.61	4.19

Conclusions

In this study, yield and yield contributing parameters of were reduced under Buriganga and Turag river water applied pots compared to normal water irrigation. The concentration of Pd, Zn and Cu in Indian Spinach crossed the standard limits of FAO and WHO, which creating a potential risk to human health. Therefore, vegetables should not be cultivated in the bank of polluted river and prevent possible health risk by ingestion of these heavy metals contaminated vegetables. Local people and farmers need to create awareness about the bad impacts of pollution of river water and use of Buriganga and Turag river water for irrigation purposes. Local government need to take some immediate steps to reduce the dispose of industrial effluents into the Buriganga and Turag river.

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