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RESEARCH ARTICLE

EFFECTIVENESS OF TEA RESIDUE TO REDUCE HEAVY METAL CONTENTS FROM INDUSTRIAL WASTE WATER

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Abstract

An experiment was conducted to investigate the physicochemical characteristics of industrial effluents and to find out the effectiveness of tea residues (TR) **for** managing **heavy** metal **pollution.** Industrial waste water samples and tea residues (waste part of tea) were used as experimental objects. The industrial waste water were collected and analyzed for metal contents. After that tea residues were used in different combination (treatments) for checking the efficacy of metal removal from waste water. The adsorption of heavy metals on tea residues was studied by batch technique with the help of AA-7000 spectrophotometer. There were ten treatments namely: T0 denotes raw water (untreated water), T1: 2g TR (tea residue) at 1 day after treated (dat), T2: 2g TR at 7th dat, T3: 2g TR at 15th dat, T4: 5g TR at 1 dat, T5: 5g TR at 7th dat, T6: 5g TR at 15th dat, T7: 10g TR at 1 dat, T8: 10g TR at 7th dat, T9: 10g TR at 15th dat. Water samples were collected in four sampling sites of four different industries located at Mymensingh city of Bangladesh. The physicochemical parameters like color, odor, pH (7.6-8.64), TDS (180-533ppm), EC (425-1692µs) and the concentration of Zn (1.861, 2.802, 3.618ppm), Cr (3.966, 2.036, 1.589ppm), Pb (6.351, 1.076, 2.789ppm) were reported. The pH and TDS were within the standard level but the EC were found much higher one sample. The concentration of heavy metals like Pb, Cr and Zn of S1, S2, S3 were higher but only S4 cannot find any toxic or traces elements. Results revealed that T8 and T9 showed the highest Zn removal rate than other treatments, where T1 treatments showed lower rate. The highest removal rate of Pb concentration showed at T9 and T6 treatments and lowest removal rate at T7 treatments for all three samples. The concentration of Cr showed higher removal rate at T9 treatments for S1 sample, T8 for S2 and T6 for S3 sample but all three samples were not so effective at T1 treatments. The results may conclude that using of tea residue may very helpful to minimize the metal pollution level for sound environment.

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Introduction:-

Presence of heavy metals in wastewater has toxic effects on the receiving environment and human health. Industrial processes produce multi component wastewater that requires advanced treatment technologies in developed countries toxic heavy elements discharged from different industrial areas along with polluted liquid waste have been successfully removed by high resolution and costly treatment methods. However, in developing countries the application of such advanced technologies for wastewater treatment is technically complex and expensive. Rapid industrialization has seriously contributed to the release of toxic heavy metals to water streams. Industrial waste constitutes the major source of various kinds of metal pollution in natural water. Heavy metals, especially copper, cadmium, cobult and zinc, present in many industrial wastewaters such as general industry and mining, pipe corrosion, paper products, fertilizers, tannaries, steel works, metal finishing and electroplating are known to have toxic effects such as arthritis or rheumatoid arthritis, mental disorders, anemia, insomnia, liver damage and heart problems to human health (Auyon et al. 2025; Aksu and Tazer, 2005, Gain et al., 2025, Usha et al., 2025; Nipa et al., 2025; Tuhin et al., 2024; Hossain et al., 2020).

In the right concentrations, many metals are essential to life. In excess, though, these same chemicals can be poisonous. Even chronic, low exposures can have serious health effects. In recent years, heavy metal pollution has become one of the most serious environmental problems. Presence of heavy metals even in traces is toxic and detrimental to both flora and fauna (Das et al., 2008). Wastewater containing Heavy metal causes detrimental effects on all forms of life upon direct discharge to the environment. Tinni et al. (2014) reported that different health problems such as skin diseases, itch, rash, cough, fever, diarrhea, headache, asthma, dizziness etc due to unplanned tanneny waste disposal. Human being truly depend on renewable fresh water for drinking, irrigation of crops, and industrial uses as well for production, transportation, recreation and waste disposal. In many regions of the world, the amount and quality of water available to meet human needs are already limited (Khalkar and Korke, 2015). Industrial waste constitutes the major source of various kinds of metal pollution in natural water. Electroplating, battery manufactures, painting, paper, pigments, fuels, photographic materials, plastic, explosive manufacturing and metalworking industries discharge large amounts of heavy metals.

It has become a challenge for researchers to seek cheaper and more effective material for heavy metals reduction. Therefore, there is increasing research interest in using alternative low-cost materials. (Thakur and Semil, 2013). Several processing techniques are available to reduce the concentrations of heavy metals in wastewater, including precipitation, flotation, ion exchange, solvent extraction, adsorption, and cementation onto iron, membrane processing and electrolytic methods (Oteroa et al., 2009). Tea is one of the most popular beverages and about 3.5 million tons of tea was consumed annually in the world. The use of tea residue as the low-cost materials was investigated as a replacement for current costly methods of removing heavy metal ions from aqueous solutions (Thakur and Semil, 2013).

However reduction of heavy metal from wastewater is currently one of the most important environmental issues being investigated. Also the heavy metal pollution problem is common in Bangladesh. Similar to other developing countries, in Bangladesh also, such advanced treatment method are not widely used due to their high cost, non-feasibility and economic disadvantage, difficult to operate and also these processes involve use of chemicals and synthetic polymers whose impact on the environment has not been entirely studied. To represent the cost effectiveness of tea residues to reduce heavy metals from industrial waste water selected representative district like-Mymensingh for this study. So it could be helpful to reduce heavy metals from waste water tea residue can be used, as a low cost and abundant source, for the removal of heavy metals and it may be an alternative to more costly materials.

Therefore, there is increasing research curiosity in using alternative low-cost materials. The use of tea residue as the low-cost materials was investigated as a replacement for recent costly methods of removing heavy metal ions from aqueous solutions (Thakur and Parmar, 2013). Various physical, chemical and biological methods have been studied with satisfactory results. The objectives of the study are to explore the physicochemical characteristics of industrial effluents and to evaluate the effectiveness of tea residues for managing heavy metal pollution in water samples.

Materials and Methods:-

Study Area:

The current experiment was carried out to study the effectiveness of tea residue to reduce heavy metals which discharged directly from Mymensingh BSCIC (Bangladesh Small and Cottage Industries Corporation) area on environment, particularly on the surface water around the discharge area. The experiment was conducted in the laboratory of the Dept. of Environmental Science, Bangladesh Agricultural University (BAU), Mymensingh, and Central lab of BAU and also the postgraduate research laboratory of the dept. of Agricultural chemistry, BAU, Mymensingh during the period from February 22, 2023 to May 20, 2024. The effluents and water samples were collected in the month of February 20, 2023 from the specific locations and were processed for subsequent experiments and for physico-chemical analysis in the laboratory.

The present study was conducted at Mymensingh BSCIC area. There are various industries in basic area. Most of them are food industries, but some chemical producing industries, toxic producing industries and also butteries manufacturing industries are grown up there. Which dumping their effluents directly discharge into drainage without any kind of treatments the most important water and soil pollution problem in this area. This is why the area has been selected.

Sampling:
This is the most important section of the study for the degree of accuracy of analytical results. Water sample were collected from the source points of the Mymensingh BSCIC area at Mashkanda. Total thirty plastic bottles were collected and washed well with distilled water 2 to 3 times and then entering 1-2 ml 95-98% sulfuric acid with water was poured in every bottles and sealed well and preserved one night. After one night preservation, every bottle was properly washed with shaking by water again. Before sampling, the bottle was rinsed with sample water 2 or 3 times and sank entirely so that the sample could represent the total characteristics of the water. The sampling time was between 11.00 am to 11.30 am. The industries released its water directly into the dumping drain. The effluents mixed water samples were taken in plastic bottles and their mouths were closed properly by avoiding air bubbles.

Processing of Samples:
Samples were collected in four sites (total 4 samples with 3 replications) from the experimental area and were labeled properly showing the location number, date of collection and time. The samples were preserved in refrigerator the laboratory for further analysis.

All glass wares (Conical flasks, Pipette, Measuring cylinders, Beakers and Test tubes etc.) used are of Borosil/Rankem. The instruments and apparatus used throughout the experiment are listed in table (Table 1) below:

Table 1:- List of Instruments used during the whole experiment.

	Instrument	**Make**
1.	pH meter	EL20 METTLER TOLEDO
2.	What man filter paper no.1	-
3.	Digital Weight Balance	SCIENTECH SP 250
4.	TDS meter	JENCO 3251
5.	EC meter	AD33 EC meter
6.	AA-7000 Atomic Absorption spectrophotometer	SIMADZU

Laboratory Analyses of Water Sample
The following observation analyses were done from the collected water samples:
1. Color
2. Odor
3. pH
4. Total Dissolved Solid (TDS)
5. Electrical Conductivity (EC)
6. Lead (Pb)
7. Cromium (Cr)
8. Zinc (Zn)

Color and Odor:
Water color was observed by necked eyes and water odor was felt with nose. The observational data were recorded for further comparison and discussion.

Total Dissolved Solids (TDS):
The Total Dissolved Solid (TDS) of the water samples were determined by digital TDS meter (JENCO 3251).

Procedure:-
1. First the electrode of TDS meter was washed out by distilled water.
2. Then 50 ml of sample was taken in a clean 100 ml beaker and immersed the electrode and waited for at least 1 minute.
3. Then TDS reading was collected from meter and written down in note book.

Electrical Conductivity (EC):
The electrical conductivity (EC) of the water sample was measured by digital EC meter (AD33 EC meter).

Procedure:-
First the electrode of EC meter was washed out by distilled water.
1. Then 50 ml of sample was taken in a clean 100 ml beaker and immersed the electrode and waited for at least 10 seconds.
2. Then EC reading was recorded from the meter and wrote down in note book.

Hydrogen Ion Concentration (P^H):
The pH of the water is a measured of a hydrogen ion scale of 0 (very acidic) to 14 (very basic), with P^H& being the neutral point through P^H meter (EL20 METTLER TOLEDO).

Procedure:
1. First the pH meter was standardized by distilled water and buffer solution.
2. Then 50 ml of sample was taken in a clean 100 ml beaker and immersed the electrode and waited for at least five minutes.
3. Then pH reading was recorded from the meter and wrote down in note book.

Analysis of Heavy Metals:
For the determination of lead, zinc and chromium concentration in water samples, at first 100 ml water sample was taken in beaker and free heat for 1 day. Then when the solution becomes 50ml turn the switch off and kept the solutions to cool. Now the sample was digested with 10ml HNO_3 and 5 ml $HCLO_4$ (HNO_3: $HCLO_4$ =2:1) was added. After mixing the solution was kept into digestion chamber at 135℃ for 200 min and the evaporation until the volume become 50 ml. Finally cool it down. Then the digest sample was filtered through a filter paper (whatman no. 41).Then the 20 ml dialution extract adding with 30ml distilled water to make up 50 ml volume was kept in 100 ml volumetric flask. And it is ready to determine the heavy metals in water sample extract was done by using an atomic absorption spectrometer (AA-7000) and standard solution made for analyzing heavy metals (Pb, Zn, Cr). And finally the results multiply with dialution factor (2.5 times) to get proper results.

Lead, Zinc and Chromium content of the water samples were determined by atomic absorption spectrometer (Model: SIMADZU, AA7000) following calibration of the equipment for every 10ml sample was include a certified reference material (CRMs) to insure QA/QC.

Preparation of Tea Residues:
Tea residues were washed and rinsed with distilled water. After drying sunlight, a part of the tea waste, were ground and sieved. Then the residues were put in sealed polyethylene for preservation for further work as design and further treatments.

Design and Layout of the Experiment:
Experiment was laid out in completely randomized design (CRD). Total treatment combination was 30(10×3).

Treatments:
There were ten (10) treatments in this experiment which are mentioned below:
T_0: Control (Untreated water)
T_1: 2g TR (tea residue) at 1 day after added
T_2: 2g TR (tea residue) at 7^{th} dat after added

T_3: 2g TR (tea residue) at 15th dat after added
T_4: 5g TR (tea residue) at 1 day after added
T_5: 5g TR (tea residue) at 7th dat after added
T_6: 5g TR (tea residue) at 15th dat after added
T_7: 10g TR (tea residue) at 1 day after added
T_8: 10g TR (tea residue) at 7th dat after added
T_9: 10g TR (tea residue) at 15th dat after added

Experimental Procedure:
This study was conducted (0 to 15) days and started at 17.07.2015 to 04.08.2015. Thirty plastic bottles were taken for testing efficiency of tea residues for heavy metal remove. About 2g, 5g and 10g different doses of tea residue were taken in 9 bottles for each. 100 ml metal contained water sample added in each plastic bottles. Another 3 empty plastic bottles were filled by 100 ml metal contained raw water. All bottles were kept in laboratory and observation was done based on different time duration as 1dat, 7dat and 15dat periods. The absorption of tea residue was stated as batch technique. The abovementioned experimental procedure was done using all metal containing water samples. Based on previous analysis of heavy metal in water samples of all stations, the number of total treatment combinations was 30.

The untreated raw water samples which was digested with 10ml HNO_3 and 5 ml $HCLO_4$ (HNO_3: $HCLO_4$ =2:1). After mixing the solution was kept into digestion chamber at 135^{0}C for 200 min and the evaporation until the volume become 50 ml. Finally cool it down. Then the digest sample was filtered through a filter paper (whatman no. 41). Then the 20 ml dialution extract adding with 30ml distilled water to make up 50 ml volume was kept in 100 ml volumetric flask. And it is ready to determine the heavy metals in water sample extract was done by using an atomic absorption spectrometer (AA-7000) and standard solution made for analyzing heavy metals (Pb, Zn, Cr). And finally the results multiply with dialution factor (2.5 times) to get proper results.

For each treated bottles the quantity of adsorbent in 50 ml of heavy metal solution after a certain time adsorbents were then separated from the solution by using filter paper (Whatman No. 41) and the residual heavy metals ions concentration in the solution was then determined by AA-7000 spectrophotometer with the help of calibration curve and the dialution factor is 2.5 times.

The experiments were conducted to investigate the relationship between the solid phase concentrations of an adsorbate, the dose of adsorbate adsorbed per unit mass of adsorbent and the solution phase concentration of the adsorbent at an equilibrium condition under constant temperature. Four solutions with different initial concentrations of (0.5, 1, 2 and 4 ppm) of each heavy metals solution (namely Zn, Cr, Pb) were prepared.

Metal ion removal (%) = [(Co – Ce) /Co] × 100
Where,
Co: initial metal ion concentration of test solution in ppm;
Ce: final equilibrium concentration of test solution in ppm;

Data Analysis:-
All the ends of data collection were compiled, tabulated and analyzed. The primary data was prepared from field investigation and laboratory analysis. Different journals, reports, research paper, searching websites from Google and other published and unpublished documents of Government and non-government etc. were helped to complete the research. Microsoft Office Excel 2010 software was used for data analysis and presentation. Finally all types of analyzed data were integrated and presented as maps, table and graphs and putted in the report (Islam et al., 2015).

Results and Discussion:-
This chapter presents the results of analysis and findings of water quality parameter and concentration of heavy metals and the effectiveness of tea residue to remove Zn, Cr and Pb from water sample at selected sites of BSCIC area of Mymensingh sadar. The physiochemical parameters are EC, pH, TDS, Cr, Zn and Pb. For water samples were collected from four sampling points from selected area which are denoted as S_1, S_2, S_3 and S_4 respectively. They are represented in this chapter and discussed under appropriate headings in the light and support of relevant available research findings whenever applicable.

Physiochemical parameters of water

Color: Color of water in the selected area was observed visually. The observe color of sample 1 was light dark, sample 2 was slightly brown, sample 3 was deep dark, sample 4 was almost colorless. According to WHO, the standard is colorless. So the water samples collected from the four selected station is contaminated because of released effluents of Mymensingh BSCIC area.

Odor: Odors of water in the selected points were felt by nose. Odor is an important physical parameter for determining the quality of water. The standard value is odorless (WHO, 2011). In this study we observed that the water in S_1, S_2 and S_3 areas were very bad smell. Which indicate very poor quality of water in BSCIC area, Mymensingh. On the other hand an odor of S4 sampling point was tolerable because near this point food industries are situated and it does not release any bad chemicals into water body.

pH: The observed pH values of four sampling points of BSCIC area of Mymensingh sadar ranged from 7.6 to 8.74 (Fig. 1), which indicated the alkaline condition of the water. From this study the lowest pH value was observed at sample 4 and the highest pH value observed at sample 3. The appropriate pH value for aquatic environment (usually fresh water) is ranging from 6.5-9.0. At pH 11.0 fish dies (Swingle, 1967). According to ADB standards the acceptable range of pH irrigated water is 6- 8.5. In the study pH in all sampling points were within the standard range. Islam et al. (2017) investigated of effluent management of the selected textile industry and to investigate the physiochemical parameters and pH was found greater than 7 which were slightly alkaline. Rahman et al. (2016) reported that the surface water quality and concentration of Balu and Brahmaputra rivers to Demra in Dhaka city and BAU campus in Mymensingh respectively and pH was found close to standard.

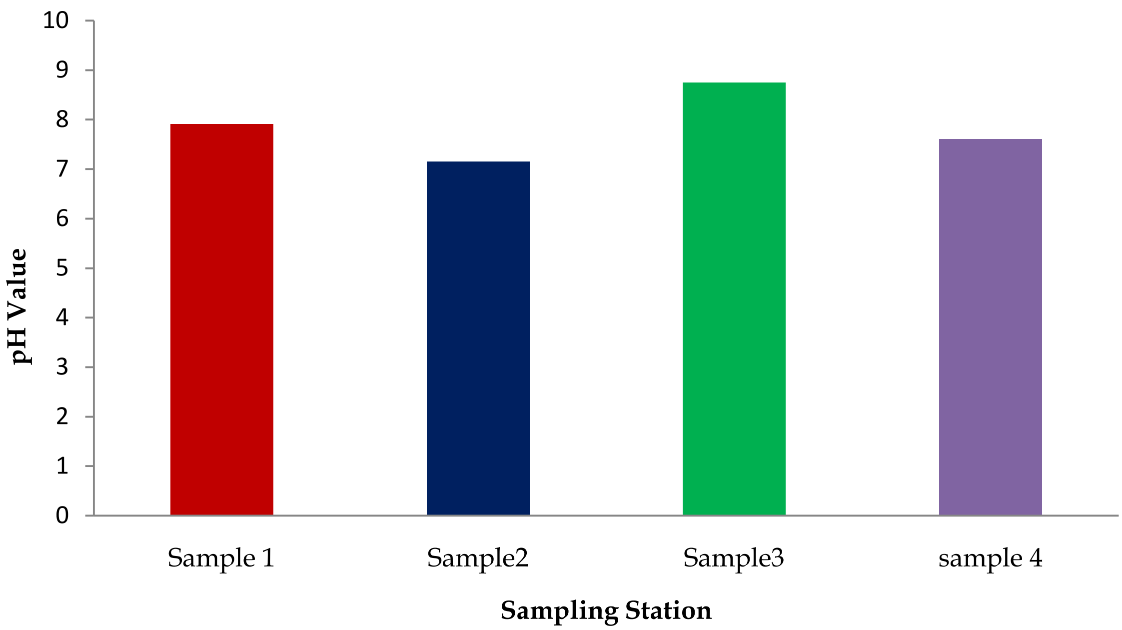

Fig. 1:- pH at different sampling station.

Total Dissolved Solids (TDS):

TDS comprise inorganic salts and organic matters. The common dissolved salts such as minerals salts claimed to affect the taste, hardness, corrosion and encrustation. Dissolved in organic substances may show adverse effects on aquatic animals and plants and also may cause irrigation problems (Alam et al., 2007). TDS mainly indicate the presence of various kinds of minerals like ammonium, nitrate, phosphate, alkalis, some acids, sulphates and metallic ion etc., which comprised both colloidal and dissolved solids in water (Kabir et al., 2002). The observed TDS values of four sampling points of BSCIC area of Mymensingh sadar ranged from 180ppm to 533ppm (Fig. 2). From this study the lowest TDS value was observed at sample 1 and the highest TDS value observed at sample 3. The appropriate TDS value for industrial water was 1500ppm (ADB, 2004) which was shown in (Appendix III). Since the TDS values were lower than acceptable range which indicates the better condition of water. Rahman et al. (2016) reported that the surface water quality and concentration of Balu and Brahmaputra rivers to Demra in Dhaka city and BAU campus in Mymensingh respectively and found TDS was (704 ± 8.54 mg/l).

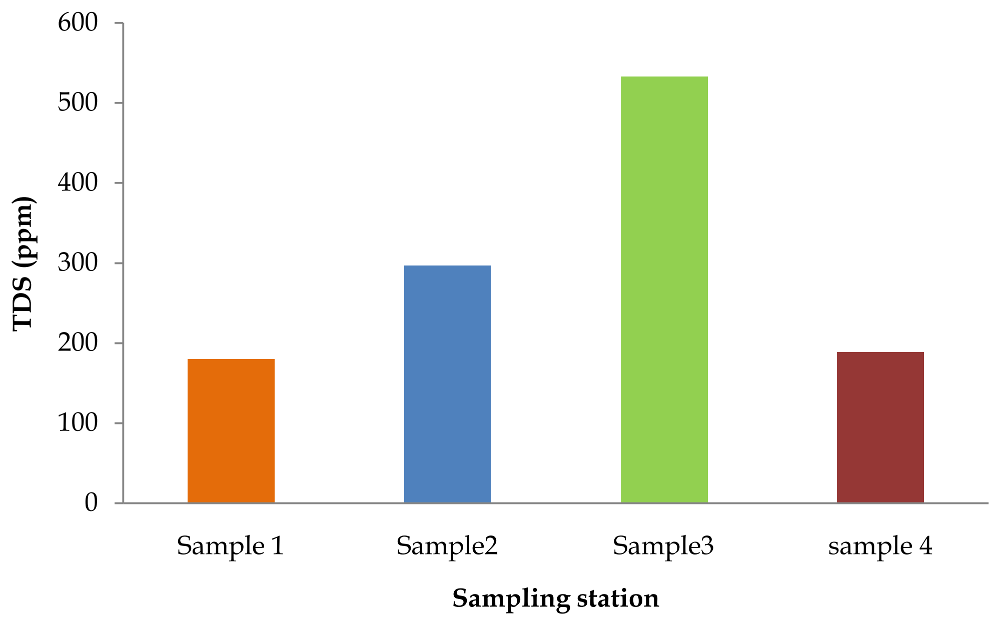

Fig. 2:- TDS at different sampling station.

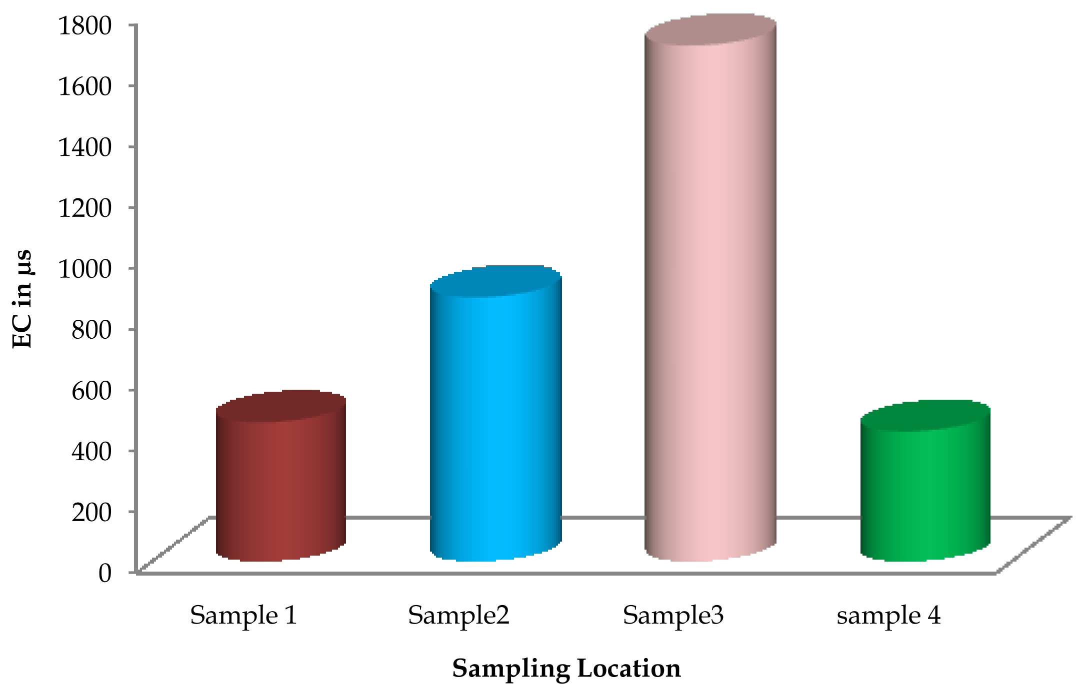

Fig. 3: EC at different sampling station

Electrical Conductivity (EC):
The electrical conductivity is the measure of capacity of a substance or solution to carry an electrical current. Its value depends on the concentration and degree of dissociation of ion as well as the temperature and migration velocity of the ion in electrical field. It is used to indicating the total concentration of ionized constituents of water (Huq and Alam, 2005). The observed EC values of four sampling points of BSCIC area of Mymensingh sadar

ranged from 425µs to 1692µs (Fig. 3). From this study the lowest EC value was observed at sample 4 and the highest EC value observed at sample 3. The appropriate EC value for fishing water was 800- 1000 µs (ADB, 2004) which was shown in (Appendix III). Since the TDS values were lower than acceptable range which indicates the water in this area contain less amount of ionic concentration. Only sample 3 is not in acceptable range, which is harmful for aquatic life.

Ali et al. (2015) carried out a study to find out the qualities of various industrial effluents with the assessment of physic-chemical parameters of water body nearby industrial area in Dhaka and found EC ranged from 2100- 9745.8 µs at various distance. Islam et al. (2017) investigated to observe the present situation of effluents of the selected textile industry and to investigated the physiochemical parameters and EC was recorded (185-193 µs/cm).

Heavy metals in water:

The observed traces elements as Chromium (Cr), Lead (Pb) and Zinc (Zn) of four sampling points of BSCIC area of Mymensingh sadar are shown in Fig. 4. From this study the variation of heavy metals are lowest in sample 4 and highest in sample 1. In sample 4 the range of heavy metals are below the detectable limit. That's why sample 4 is not needed for treatment. On the other hand Sample 1, 2 and 3 were observed with exceeded concentration of heavy metals presented in water sample which is 3.996ppm, 6.3507ppm and 1.861ppm for sample 1 respectively. For sample 2 Cr, Pb and Zn concentration are 2.036ppm, 1.076ppm and 2.802ppm respectively. For sample 3 Cr, Pb and Zn concentration are 1.598ppm, 2.8152ppm and 3.618ppm respectively. In this study showed that sample 4 situated near the food industry discharge point. Thus this point cannot find any toxic or traces elements but other point situated various chemical industries and plastic industries is found high concentration of heavy metals which is needed to be treated. Islam et al. (2017) investigated to observe the present situation of effluents of the selected textile industry and to investigated the physiochemical parameters and Pb, Zn and Ni were found 0.33 to 0.97ppm, 0.69 to 1.28ppm and 0.8 to 5.0mg/l respectively.

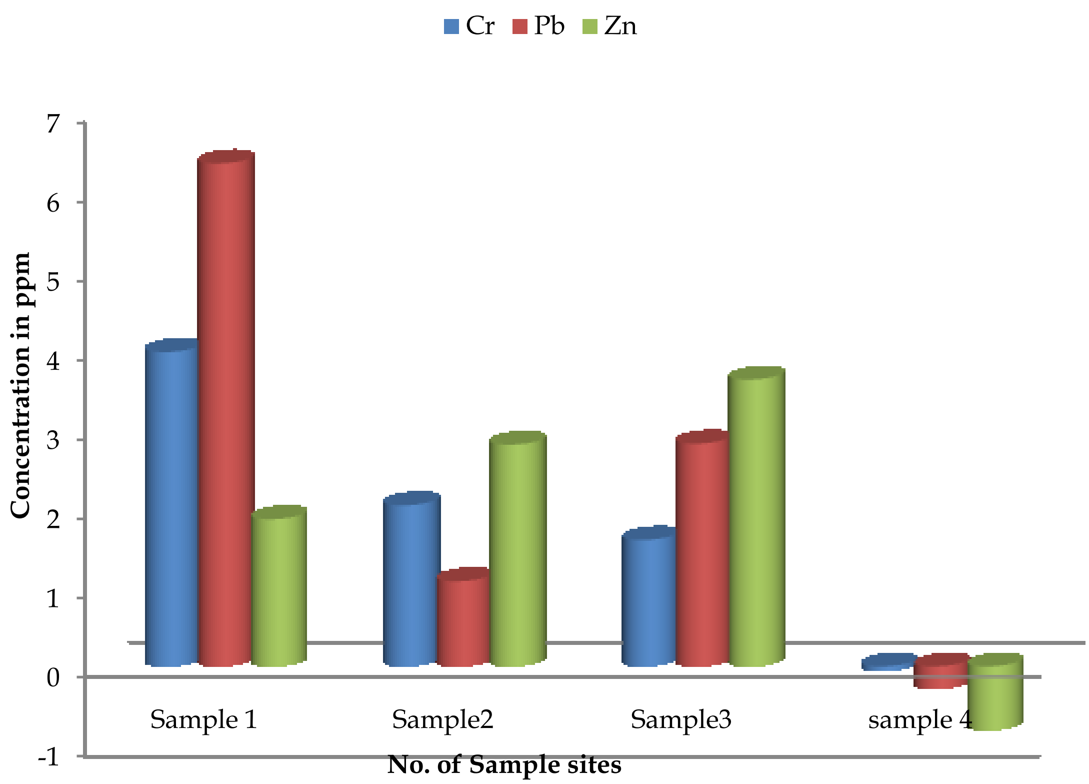

Fig. 4:- Heavy metal content at different sampling station.

Effectiveness of different doses of tea residues for heavy metal removal from waste water

Lead (Pb): The observed Lead (Pb) concentration of three sampling points of BSCIC area which is indicated as T_0 (raw water) treatments were 6.351, 1.076, 2.815ppm respectively (Fig. 5). From this study the lowest Pb value was observed at sample 2 and the highest Pb value observed at sample 1. According to Sattar (1996), the permissible conc. of Pb in fresh water is 0.668ppm. But present findings are not within the level. The concentration of Pb is remarkably higher than the standard value of Sattar (1996).

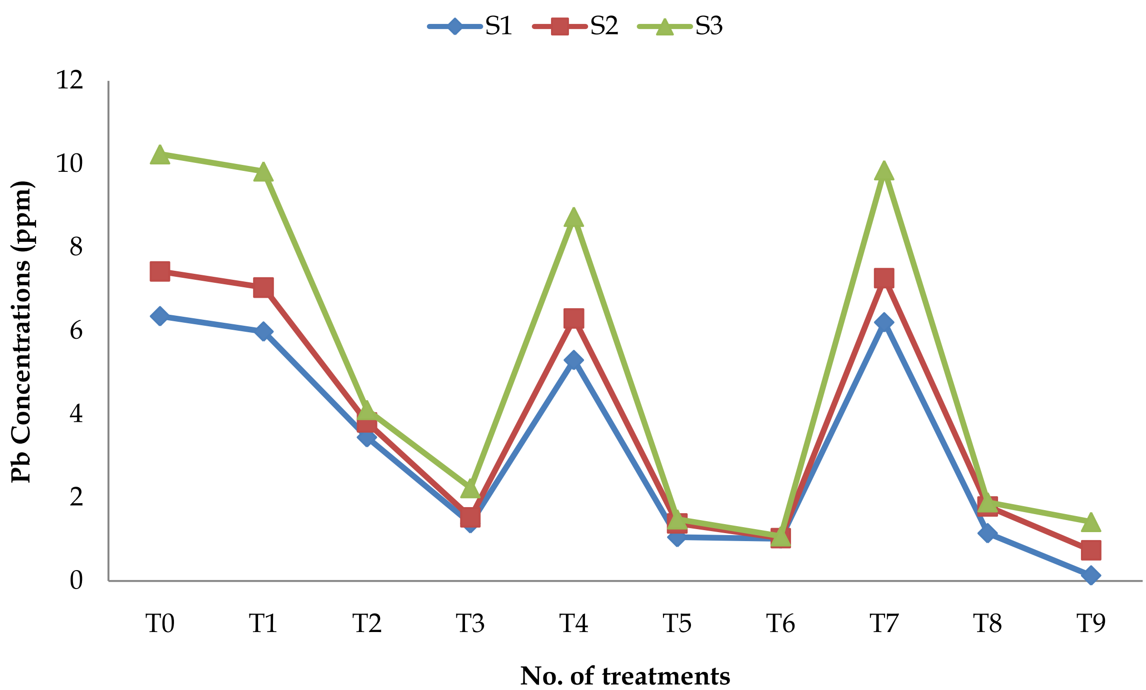

Fig. 5:- Showing effectiveness of tea residue using different dosage and time duration on the removal rate of Lead (Pb). $\mathbf{T_0}$ denotes raw water (untreated water), $\mathbf{T_1}$: 2g TR (tea residue) at 1 day after added, $\mathbf{T_2}$**:** 2g TR (tea residue) at 7th dat after added, $\mathbf{T_3}$**:** 2g TR (tea residue) at 15th dat after added, $\mathbf{T_4}$**:** 5g TR (tea residue) at 1 day after added, $\mathbf{T_5}$**:** 5g TR (tea residue) at 7th dat after added, $\mathbf{T_6}$**:** 5g TR (tea residue) at 15th dat after added, $\mathbf{T_7}$**:** 10g TR (tea residue) at 1 day after added, $\mathbf{T_8}$**:** 10g TR (tea residue) at 7th dat after added, $\mathbf{T_9}$**:** 10g TR (tea residue) at 15th dat after added. $\mathbf{S_1}$**,** $\mathbf{S_2}$ and $\mathbf{S_3}$ are three samples.

Thus tea residue is used as a natural low cost material to eliminate the heavy metal content into the waste water. In present study I was observed that Pb concentration removed after using tea residue with different dosage with 2g, 5g and 10g and different time duration as 1dat, 7dat and 15dat respectively. The removal rate of Pb concentration for S1 (sample-1) ranged 0.133ppm to 6.205 ppm and it was 5.983, 3.447, 1.382, 5.299, 1.051, 1.017, 6.205, 1.145 and 0.133ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 5). Removal rate of Pb concentration was highest in T_9 treatment and lowest in T_7 treatment. For S1 sample at T_9 treatment (15th DAT duration with 10g TR) was very effective to removed of Pb concentration where at T_7 treatment was very slow to reduced of Pb concentration in raw water.

The removal rate of Pb concentration for S2 (sample-2) ranged 0.012ppm to 1.064 ppm and it was 1.057, 0.357, 0.143, 1.002, 0.329, 0.012, 1.064, 0.643 and 0.606ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 5). Removal rate of Pb concentration was highest in T_6 treatment and lowest in T_7 treatment. Here, 5g dose for 15 days period was highly reduced Pb concentration in raw water. This treatment is best for S_2. On the other hand, 10g TR for 1 DAT was not much effective to remove Pb concentration in raw water.

The removal rate of Pb concentration for S_3 (sample-3) ranged 0.044ppm to 2.789ppm and it was 2.789, 0.301, 0.703, 2.439, 0.1002, 0.044, 2.589, 0.101 and 0.678ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 5). Removal rate of Pb concentration was highest in T_6 treatment and lowest in T_7 treatment. Here, 5g dose for 15 days period was highly reduced Pb concentration in raw water. This treatment is best for S_3. On the other hand, 10g TR for 1 DAT was not much effective to remove Pb concentration in raw water.

According to Ahluwalia and Goyal (2005) reported that studies concerning the removal of lead, iron and zinc by waste tea leaves from a multi metallic mixture containing 30mg/l of Pb, 21.5mg/l of Fe and 10mg/l of Zn revealed a 92.5,84 and 73.2% removal of Pb, Fe and Zn respectively. According to Thakur and Semil (2013) also reported that the higher the percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents due to the greater availability of the exchangeable sites or surface area. It is observed that there is a sharp increase in percentage removal with adsorbent dose for Cd^{2+}, Cr^{6+} and Pb^{2+} ions. The maximum removal of Cr^{6+}, Pb^{2+} are 83% and 93% respectively at 4 gram dose amount of rice husk adsorbent and from maximum removal Cd^{2+} is 92% at 3 gram adsorbent dose. Rahman et al. (2016) reported that the surface water quality and concentration of Balu and Brahmaputra rivers to Demra in Dhaka city and BAU campus in Mymensingh respectively and found Pb (0.032± 0.003mg/l).

Chromium (Cr):

The observed Chromium (Cr) concentration of three sampling points of BSCIC area which is indicated as T_0 (raw water) treatments were 3.966, 2.036, 1.598ppm respectively (Fig. 6). From this study the lowest Cr value was observed at S_3 and the highest Cr value observed at S1. Rahman et al., (2013), reported that the conc. of Cr in discharge inland water 0.5ppm. But present findings are not within the level. The concentration of Cr is remarkably higher than the standard value of Rahman et al., (2013).

Thus tea residue is used as a natural low cost material to eliminate the heavy metal content into the waste water. In present study I was observed that Cr concentration removed after using tea residue with different dosage with 2g, 5g and 10g and different time duration as 1dat, 7dat and 15dat respectively. The removal rate of Cr concentration for S_1 (sample-1) ranged 0.776ppm to 3.244ppm and it was 3.244, 2.806, 2.141, 2.866, 1.659, 1.578, 2.804, 0.784 and 0.776ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 6). Removal rate of Cr concentration was highest in T_9 treatment and lowest in T_1 treatment. For S_1 sample at T_9 treatment (15^{th} DAT duration with 10g TR) was very effective to removed of Cr concentration where at T_1 treatment was very slow to reduced of Cr concentration in raw water.

The removal rate of Cr concentration for S_2 (sample-2) ranged 0.241ppm to 2.022ppm and it was 2.022, 1.087, 1.873, 1.879, 0.985, 0.885, 1.498, 0.241 and 0.419 ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 6). Removal rate of Cr concentration was highest in T_8 treatment and lowest in T_1 treatment. Here, 10g dose for 7 days period was highly reduced Cr concentration in raw water. This treatment is best for S_2. On the other hand, 2g TR for 1 DAT was not much effective to remove Cr concentration in raw water.

The removal rate of Cr concentration for S3 (sample-3) ranged 0.919ppm to 1.496ppm and it was 1.496, 1.098, 0.966, 1.316, 0.995, 0.919, 1.251, 0.978 and 0.966ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 6). Removal rate of Cr concentration was highest in T_6 treatment and lowest in T_1 treatment. Here, 5g dose for 15 days period was highly reduced Cr concentration in raw water. This treatment is best for S_3. On the other hand, 2g TR for 1 DAT was not much effective to remove Cr concentration in raw water.

According to Ahluwalia and Goyal (2005) reported that studies concerning the removal of lead, iron and zinc by waste tea leaves from a multi metallic mixture containing 30mg/l of Pb, 21.5mg/l of Fe and 10mg/l of Zn revealed a 92.5,84 and 73.2% removal of Pb, Fe and Zn respectively. According to Thakur and Semil (2013) also reported that the higher the percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents due to the greater availability of the exchangeable sites or surface area. It is observed that there is a sharp increase in percentage removal with adsorbent dose for Cd^{2+}, Cr^{6+} and Pb^{2+} ions. The maximum removal of Cr^{6+}, Pb^{2+} are 83% and 93% respectively at 4 gram dose amount of rice husk adsorbent and it showed that 7 maximum removal Cd2+ is 92% at 3 gram adsorbent dose. Rahman et al. (2016) reported that the surface water quality and concentration of Balu and Brahmaputra rivers to Demra in Dhaka city and BAU campus in Mymensingh respectively and found Cr (0.02±0.003 mg/l).

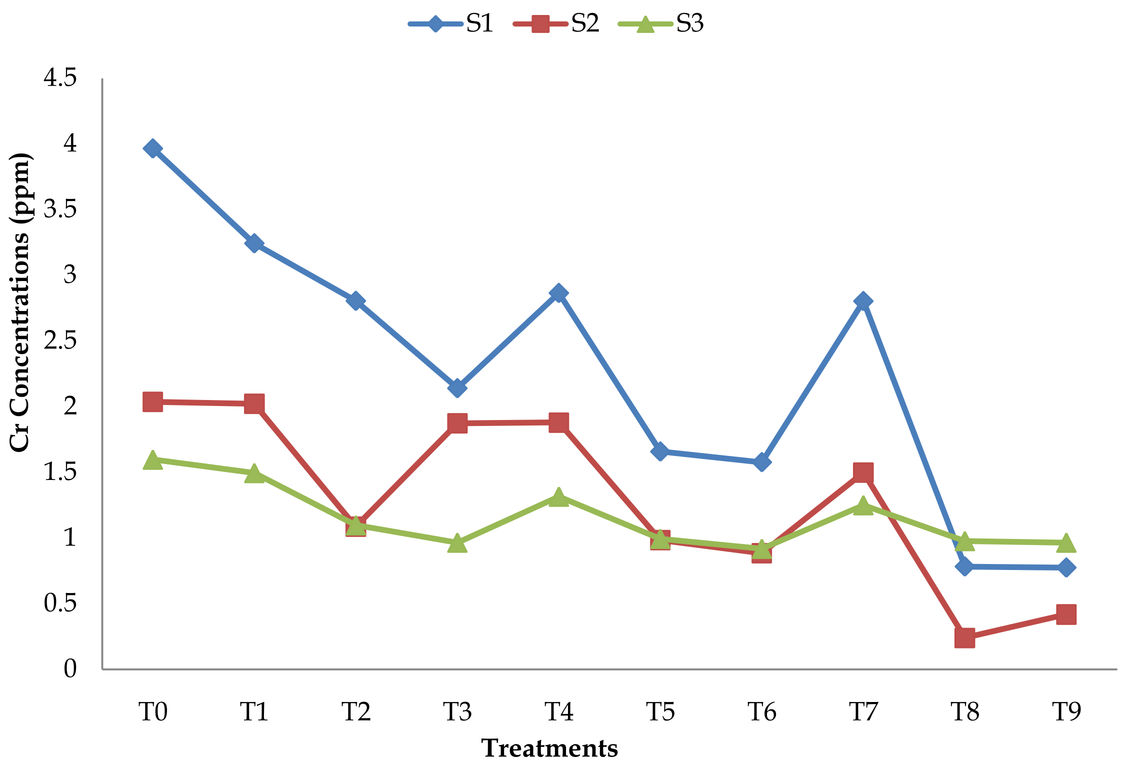

Fig. 6:- Showing effectiveness of tea residue using different dosage and time duration on the removal rate of Chromium (Cr). Here, T_0 denotes raw water (untreated water), T_1: 2g TR (tea residue) at 1 day after added, T_2: 2g TR (tea residue) at 7th dat after added, T_3: 2g TR (tea residue) at 15th dat after added, T_4: 5g TR (tea residue) at 1 day after added, T_5: 5g TR (tea residue) at 7th dat after added, T_6: 5g TR (tea residue) at 15th dat after added, T_7: 10g TR (tea residue) at 1 day after added, T_8: 10g TR (tea residue) at 7th dat after added, T_9: 10g TR (tea residue) at 15th dat after added. S_1, S_2 and S_3 are three samples.

Zinc (Zn):
The observed Zinc (Zn) concentration of three sampling points of BSCIC area which is indicated as T_0 (raw water) treatments were 1.86, 2.802, 3.618ppm respectively (Fig. 7). From this study the lowest Zn value was observed at S1 and the highest Zn value observed at S3. According to Sattar (1996), the permissible conc. of Zn, in fresh water is 0.047ppm. But present findings are not within the level. The concentration of Zn is remarkably higher than the standard value of Sattar (1996).

Thus tea residue is used as a natural low cost material to eliminate the heavy metal content into the waste water. In present study I was observed that Zn concentration removed after using tea residue with different dosage with 2g, 5g and 10g and different time duration as 1dat, 7dat and 15dat respectively. The removal rate of Zn concentration for S1 (sample-1) ranged 0.458ppm to 1.854ppm and it was 1.854, 1.251, 0.905, 1.484, 0.789, 0.728, 1.287, 0.458 and 0.505ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 7). Removal rate of Zn concentration was highest in T_8 treatment and lowest in T_1 treatment. For S1 sample at T_8 treatment (7th DAT duration with 10g TR) was very effective to removed of Zn concentration where at T_1 treatment was very slow to reduced of Zn concentration in raw water.

The removal rate of Zn concentration for S_2 (sample-2) ranged 0.378ppm to 2.789ppm and it was 2.789, 1.419, 1.709, 1.848, 0.952, 0.875, 1.725, 0.429 and 0.378ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 7). Removal rate of Zn concentration was highest in T_9 treatment and lowest in T_1 treatment. Here, 10g dose for 15 days period was highly reduced Zn concentration in raw water. This treatment is best for S_2. On the other hand, 2g TR for 1 DAT was not much effective to remove Zn concentration in raw water.

The removal rate of Zn concentration for S_3 (sample-3) ranged 0.657ppm to 3.509ppm and it was 3.509, 1.623, 2.521, 1.725, 1.757, 1.711, 2.225, 0.657 and 0.805ppm in T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 treatments respectively (Fig. 7). Removal rate of Zn concentration was highest in T_8 treatment and lowest in T_1 treatment. Here, 10g dose for 7th DAT period was highly reduced Zn concentration in raw water. This treatment is best for S_3. On the other hand, 2g TR for 1 DAT was not much effective to remove Zn concentration in raw water.

According to Ahluwalia and Goyal (2005) reported that studies concerning the removal of lead, iron and zinc by waste tea leaves from a multi metallic mixture containing 30mg/l of Pb, 21.5mg/l of Fe and 10mg/l of Zn revealed a 92.5,84 and 73.2% removal of Pb, Fe and Zn respectively. According to Thakur and Semil (2013) also reported that the higher the percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents due to the greater availability of the exchangeable sites or surface area. It is observed that there is a sharp increase in percentage removal with adsorbent dose for Cd^{2+}, Cr^{6+} and Pb^{2+} ions. The maximum removal of Cr^{6+}, Pb^{2+} are 83% and 93% respectively at 4 gram dose amount of rice husk adsorbent and it showed that maximum removal Cd2+ is 92% at 3 gram adsorbent dose.

Here, this study it was observed that the lowest removal rate of Zn conc. is 2g of 1dat for all three samples and highest removal rate of Zn conc. is good at T_8 and T_9 of all three samples (Fig. 4.7). In some cases the amount of metal ions adsorbed per unit weight of adsorbent decreases with the adsorbent dose. This is due to the fact that at higher adsorbent dose the solution ion concentration drops to a lower value and the system reaches equilibrium at lower values of indicating the adsorption sites remain unsaturated (Bose et al., 2002). Rahman et al. (2016) reported that the surface water quality and concentration of Balu and Brahmaputra rivers to Demra in Dhaka city and BAU campus in Mymensingh respectively and found Zn (0.08±0.005 mg/l).

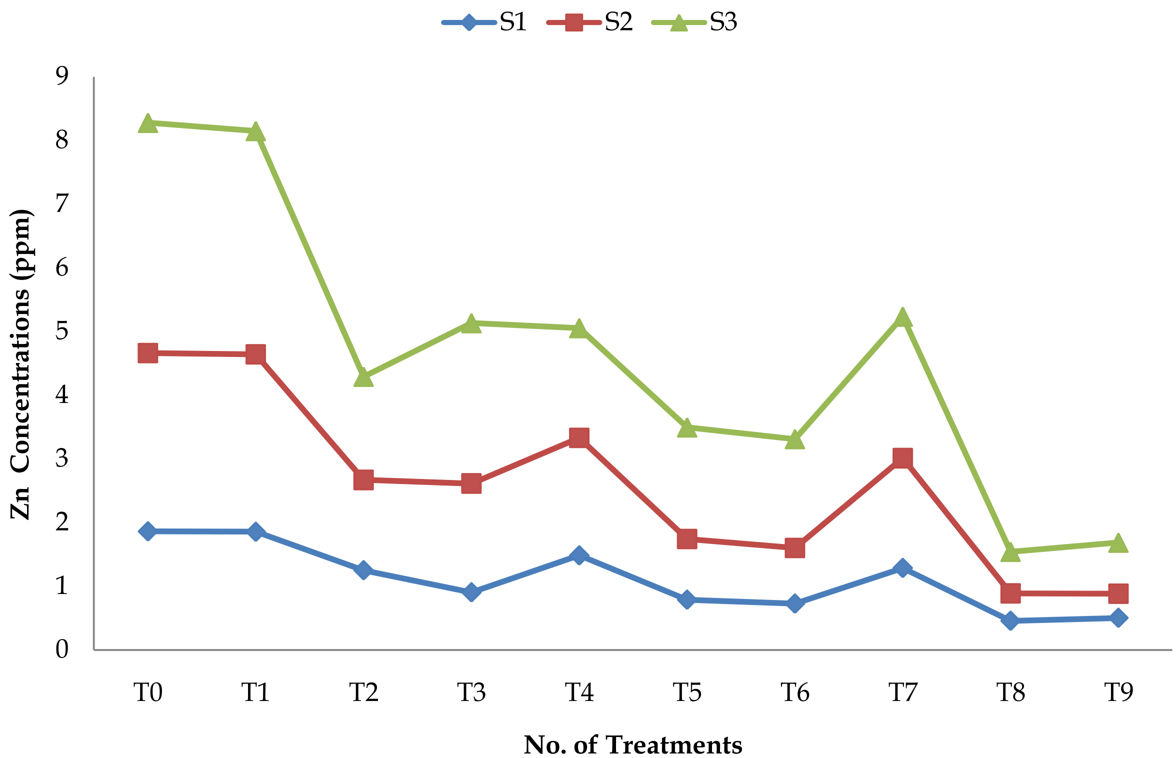

Fig. 7:- Showing effectiveness of tea residue using different dosage and time duration on the removal rate of Zinc (Zn) Conc. Here, T_0 denotes raw water (untreated water), T_1: 2g TR (tea residue) at 1 day after added, T_2: 2g TR (tea residue) at 7th dat after added, T_3: 2g TR (tea residue) at 15th dat after added, T_4: 5g TR (tea residue) at 1 day after added, T_5: 5g TR (tea residue) at 7th dat after added, T_6: 5g TR (tea residue) at 15th dat after added, T_7: 10g TR (tea residue) at 1 day after added, T_8: 10g TR (tea residue) at 7th dat after added, T_9: 10g TR (tea residue) at 15th dat after added. **S1, S2** and **S3** are three samples.

Conclusion:-

The present study was conducted to investigate the determination of physiochemical characteristics of industrial effluents and observe the effectiveness of tea residues for reducing heavy metals pollution in waste water which is directly discharge from BSCIC area Mymensingh. Various parameters were compared with standard values for irrigation, fishing and industrial water. Disposal of the waste from BSCIC area of Mymensingh district is major problem because it causes water pollution. Tea waste is a good option as it is a low cost adsorbent for removal of heavy metals contents from waste water. Many studies shows their efficiency which is nearly 100%.Tea waste is found to be good adsorbent for metals like Ni, Zn, Cr, Cu, Pb etc. Now a day it is important to prevent water pollution due to heavy metals. Research is now focused to develop a suitable technology either to prevent heavy metal pollution or to reduce it to low level. The most of chemical, plastic, paper and food related industries are running in BSCIC area of Mymensingh district in Bangladesh use a large amount of water by discharging effluents into the streams and rivers by polluting nearby water resources.

The experiment was carried out in a completely randomized design (CRD) with three replications. The experiment was carried out in plastic bottle. Water samples were collected in distinct four sampling sites which were denoted as S_1, S_2, S_3 and S_4. The physiochemical parameters like color, odor, pH, total dissolved solid (TDS), electrical conductivity (EC) and the concentration of heavy metals (Pb, Cr, Zn) were analyzed. The study reported that pH and TDS were within the standard level but the EC were found much higher at S_3 sample. The study also reported that the concentration of heavy metals like Pb, Cr and Zn of S_1, S_2, S_3 were higher but only S4 cannot find any toxic or traces elements. The study also revealed that the adsorption of heavy metals on tea residue was studied by batch technique with the help of AA-7000 spectrophotometer. Total treatment combination was 30(10×3). There were total ten treatments. The study reported that the lowest removal rate of Zn conc. is at 2gm tea residues added after 1 dat for all three samples and highest removal rate of Zn conc. is good at two treatments, 10gm tea residues at 7th and 15th dat time duration of all three samples. For removal of Pb conc. the highest removal rate is good at also two treatments, 5gm tea residue at 15th dat and 10gm tea residues at 15th dat time duration for all three samples. The lowest removal rate of Pb conc. is 10gm tea residues at 1dat for among all the samples. The study finally reported that the lowest removal rate of Cr conc. is good at 10gm tea residues at 15th dat time duration for S_1 sample, 10gm tea residues at 7th dat for S_2 and 5gm tea residues at 15th dat for S_3 sample but all three samples were not so effective at 2gm tea residues at 1 dat treatments.

In current years, environment has been contaminated heavily because of discharging industrial effluent containing heavy metals. Environmental legislation has been accustomed control the value of industrial discharge that comprises toxic metals. To avoid environmental threats, it is crucial to get rid of metal contaminants from industrial effluents before discharging in water bodies. The noxious metals present in the discharge are non-biodegradable and generally lethal to living organisms. Conventional methods of precipitation and elimination are increasingly getting expensive and not systematically efficient in all cases, so alternate strategy of adsorption has been visualized for capturing of materials by low cost adsorbents. Overview of this review study clarifies that adsorption technique is a cost effective and technically feasible method. Replacement of expensive adsorbent by low cost, more effective and readily available waste by- product as adsorbent e.g., tea waste, is very operative to minimize the pollution level caused by BSCIC area of Mymensingh. The most widely used conventional methods for removing heavy metals have many disadvantage such as high capital and operational cost, not suitable for small–scale industries and inadequate efficiency. Adsorption is one of the promising processes for the removal of heavy metals from wastewater. Activated carbon is used by many industries as an adsorbent of Pb, Zn and other heavy metals but the cost is major draw of this adsorbent. Therefore increasing the use of low cost adsorbent for the removal of heavy metals like agricultural waste like coconut husk, rice husk, almond husk etc, biomaterial from marine algae, mango seed shell powder. In the recent year focus has been on the tea waste. It is recommended that tea waste can be used, as a low cost and abundant source, for the removal of heavy metals and it may be an alternative to more costly materials. Studies showed that the other results are also improved the effectiveness of tea waste to minimize water pollution level.

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