Assessment of Hexavalent Chromium Pollution in Buriganga and Dhaleshwari River Waterbodies Adjacent to Tannery Estates in Bangladesh

Hafizur Rahman¹, Nabila Hoque², Palash K. Sarker³, and Ashrafus Safa⁴

¹²Department of Environmental Science, SESM, Independent University, Bangladesh (IUB), Dhaka, Bangladesh
³Department of Science and Humanities, Military Institute of Science and Technology (MIST), Dhaka, Bangladesh
⁴School of Life Sciences, Independent University, Bangladesh (IUB), Bangladesh

emails: ¹hrahman@iub.edu.bd; ²nabilahoq111@gmail.com; ³sarker@sh.mist.ac.bd; and ⁴asafa@iub.edu.bd

ARTICLE INFO

Article History:
Received: 22nd February 2020
Revised: 18th March 2020
Accepted: 31st March 2020
Published online: 21st July 2020

Keywords:
Chromium
Tannery
Effluent
Buriganga
Dhaleshwari

ABSTRACT

Recently, in Bangladesh, all tannery industries have been relocated to a new location exclusively established for leather processing industries with modern manufacturing facilities and effluent treatment plants with standard probations. Effluents generated from the tannery industries are now being disposed of into the surrounding river water bodies. In this study, our goal was to investigate the presence of chemical contaminants like hexavalent chromium (Cr⁶⁺) in the water bodies surrounding tannery industries and to understand the possible role played by the tannery effluents in contaminating the river water bodies with Cr⁶⁺. Result analysis revealed the presence of an amount of Cr⁶⁺ (ranging from 0.01 mg/L to 3.54 mg/L) in the surrounding water bodies, which was far above the maximum permissible limit of Cr⁶⁺ (0.05 mg/L for surface water), set by the Environmental Protection Agency. It is, therefore, plausible to assume that effluents from the tanneries play an important role in hexavalent chromium contamination of water bodies surrounding tannery industries.

1. INTRODUCTION

Leather industry is one of the key export sectors in Bangladesh. Currently, > 270 registered tanneries are operating in Bangladesh (Rouf et al., 2013; Blacksmith Institute and Green Cross Switzerland, 2013; Hashem et al., 2014). Majority tanneries are situated at Hazaribagh area, located one and a half kilometer northeast to the river Buriganga in Dhaka, as shown in Figure 1 (Shams et al., 2009). A portion of the effluents from tanneries in Hazaribagh are transported to the lagoon while the other portion discharged into nearby low-lying areas through drain, which eventually falls into the Buriganga and introducing significant hazards in the surrounding environment (Hashem et al., 2015). It has already been reported that these tanneries discharge 1.6 tons of chromium per day, of which 0.35 tons are deposited into the lagoons and the remaining amount end up in the Buriganga (Karim et al., 2013). Generally, tannery waste contains both hexavalent and trivalent forms of chromium which are most stable and exist in the aqueous system. The hexavalent chromium is more toxic than its trivalent form and it is of particular concern for being carcinogenic and mutagenic to living organisms (Holmes et al., 2008; Saha et al., 2011; Zewdu & Amare, 2018). In addition, highly toxic heavy metals such as copper, zinc, arsenic, cadmium, lead and organic compounds such as phenols, hydrocarbons and other toxic chemicals are found in Hazaribagh tannery area. (Shams et al., 2009; Karim et al., 2012; Tinni et al., 2014; Sarkar et al., 2015; Asaduzzaman et al., 2016; Juel et al., 2016). Exposure to these chemicals causes adverse health effects when they are not metabolized by the body and accumulated in the soft tissues. (Singh et al., 2004; Wilson and Pyatt, 2007). A number of residents in Hazaribagh were affected by pollution resulted from toxic chemicals, particularly chromium (Blacksmith Institute & Green Cross Switzerland, 2013; Hossain & Islam, 2016).

Considering the hazardous impact of tannery wastes on human and environment in Hazaribagh, Bangladesh government has planned a new strategy to resettle the tannery factories from their contemporary location to a new spot in Savar, which is known as ‘Hazaribagh Tannery Relocation Project (HTRP)’ (Jolly et al., 2012, Mahmood et al., 2017). The main focus of this relocation is to modernize the tanneries, and to treat the effluents through a modern common effluent treatment plant (CETP) before disposing of in the river water, which would finally evolve an appropriate waste management system for tannery industry. It is mentionable that Savar is an Upazila of Dhaka District,
which is bounded to the west and south by the river Dhaleshwari, a linked river of Buriganga and the CETP is 20 kilometers far from Hazaribagh tannery area (RPMC, 2008; Islam et al., 2015). Therefore, contaminants might be transported with the water flow between these two rivers.

In the present study, we aim to determine the concentration of \(Cr^{6+}\) in the Buriganga and Dhaleshwari rivers from Hazaribagh and Savar tannery estates, respectively. The obtained data from this study will be helpful to understand the contamination level of the water bodies, that will facilitate to create people’s awareness of chromium contamination from tannery waste disposal. Moreover, this study will be beneficial for the newly relocated tannery estate to make it more sustainable.

2. METHODOLOGY

A. Sampling Site

All the samples were collected from different categorized locations that are representative of the river flow, water source, drainage points, and treatment plant as shown in Figure 2 (a) and (b). There are two different study areas as shown in Figure 3 (a) and (b) for this project. All the samplings have been taken from the mentioned two areas, i.e., the Buriganga riverine area in Hazaribagh tannery estate and the Dhaleshwari riverine area in Savar tannery estate. The water samples were collected from 20 feet depth in each point which was marked by a global positioning system (Garmin eTrex10) for future reference. It is mentionable that all the samples were taken at the rainy season between June and July while the water dilution of the rivers was much higher than the dry season.

B. Reagents and Solutions

All chemicals were of analytical-reagent grade and purchased from Sigma-Aldrich. Deionized water was used in the preparation of various solutions. A stock solution of potassium dichromate (\(K_2Cr_2O_7\)) of 1000 mg/L was prepared by weighing out an appropriate amount and dissolving it in deionized water. Working standards were prepared by consecutive dilution. Diphenylcarbazide solution was prepared by dissolving 1 g of 1,5-diphenylcarbazide (DPC), \(CO(NH)_2HC_6H_5\), in 100 mL acetone and acidified with a drop of acetic acid.

C. UV Absorbance Measurement

In this process, 20 mL of the sample was acidified with 1 mL of sulfuric acid and 1 mL of nitric acid. Then the sample was boiled properly for 10 minutes followed by cooling. The sample was then filtered with filter paper. Then the filtrate was taken into a volumetric flask and it was diluted with deionized water to adjust the volume into 20 mL. After that, 2 drops of methyl orange were added in that adjusted 20 mL sample solution and the sample solution became orange in colour. Then the sample solution was titrated consecutively, firstly with a 28% ammonia solution until the colour turned yellow and secondly with 1:1 sulfuric acid solution until the colour turned back into orange. After that the sample was boiled and cooled down, 2 drops of potassium dichromate was added to it followed by boiling. The colour of the sample turned into purple at this time. Then 1 mL of sodium azide was added followed by boiling again. All the colour had to disappear properly after the boil. If the colour did not disappear, another 1 mL of sodium azide was added to make the sample entirely colourless. The sample was properly cooled down to room temperature and 0.25 mL of orthophosphoric acid was added into the sample solution. The pH level of the solution was found between 1.7 – 1.3. Then, 20 mL of this solution was taken into another volumetric flask followed by the addition of 2 mL of sulfuric acid (0.2 N) and 2 mL of DPC solution. The volume of the solution was adjusted again to 50 mL with deionized water. In this method, \(Cr(VI)\) was reacted with DPC in acidic conditions and formed a purple-coloured species. As a result of a redox reaction, \(Cr(VI)\) was reduced to \(Cr(III)\), and DPC was oxidized to 1,5-diphenylcarbazone as shown in Figure 4. Finally, the wavelength of UV-Vis spectrophotometer (HACH, DR2800) was adjusted at 540 nm to measure the absorbance of the samples (Onchoke & Sasu, 2016).
3. RESULTS AND DISCUSSION

$Cr^{6+}$ was detected in both study areas. However, the concentration was alarming in the drainage streams of Hazaribagh, because of the huge amount of basic chromium sulfate which is discharged from the adjacent leather processing and tanning industries. The effluents generated from those tanneries are dumped either directly into the nearby Buriganga river without any treatment or through drainage system. Sometimes, the industries use small lagoons to keep their effluents temporarily. Solid wastes are managed through open dumping methods near the industries or river and leachate comes in the environment very often. However, all the effluents discharged from the tanneries somehow end up in the Buriganga river through point and non-point sources.

The detected concentration of $Cr^{6+}$ in the samples collected from Hazaribagh area were ranging from 0.01 mg/L to 3.54 mg/L as shown in Table 1 and Table 2.

<table>
<thead>
<tr>
<th>Sampling points</th>
<th>Hazaribagh area</th>
<th>Savar area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trend FS</td>
<td>0.055</td>
<td>0.044</td>
</tr>
<tr>
<td>Trend MS</td>
<td>0.174</td>
<td>0.030</td>
</tr>
<tr>
<td>Trend OS</td>
<td>0.192</td>
<td>0.034</td>
</tr>
<tr>
<td>Impact FS</td>
<td>0.032</td>
<td>0.022</td>
</tr>
<tr>
<td>Impact MS</td>
<td>0.100</td>
<td>0.029</td>
</tr>
<tr>
<td>Impact OS</td>
<td>0.017</td>
<td>0.050</td>
</tr>
<tr>
<td>Base FS</td>
<td>0.052</td>
<td>0.038</td>
</tr>
<tr>
<td>Base MS</td>
<td>0.051</td>
<td>0.035</td>
</tr>
<tr>
<td>Base OS</td>
<td>0.010</td>
<td>0.029</td>
</tr>
</tbody>
</table>
of Cr\textsuperscript{6+} in Savar area (Figure 6) might cause due to the less efficiency of the newly established CETP or through the advection of the water flows between two rivers, the Buriganga and the Dhaleshwari. The river channels are also connected with each other, as shown in Figure 1. The distance between these two rivers is only 20 kilometers. So, the heavy metal chromium may travel through the water current by advection. Besides, chromium from the tannery waste can be leached into nearby soil and water, which could finally be the cause of the presence of Cr\textsuperscript{6+} with a meager amount in the Dhaleshwari river water. However, when all the tannery industries will be shifted to the new location and if the CETP fails to treat the effluents efficiently, the scenario would be the same as Hazaribagh.

### 4. CONCLUSIONS

The results of this study suggest that chromium (Cr\textsuperscript{6+}), a carcinogenic chemical released from tannery waste, is being introduced to Buriganga river water through different water bodies at Hazaribagh area. Consequently, it has been listed as one of the polluted places in Dhaka city. It is plausible that the removal of Hazaribagh tannery may reduce the Buriganga river pollution by a massive percentage. Relocation of all tanneries from Hazaribagh to Savar implemented by BSCIC (i.e., Bangladesh Small and Cottage Industries Corporation) with a properly designed and controlled new industrial estate will facilitate an ecologically friendly tannery business park in Bangladesh. So far, the results of our present study support so, especially considering the chromium contamination.

### ACKNOWLEDGEMENTS

The authors are grateful to Ms. Shaheda Begum, Ms. Sonia Afzana, and Mr. Syed Ahmmed Kabir, Department of Environment, Government of the People’s Republic of Bangladesh, Agargaon, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh, for their help in the sample collection and laboratory experiments. The authors would also like to thank Ms. Kazi Sunzida Lisa, Department of Environmental Management, Independent University Bangladesh (IUB), for her help to draw the GIS map.

### REFERENCES


