Entry to the

Stockholm Junior Water Prize – 2020

AERATION of Flowing Water Bodies and Application of Feasible Purification Methods to Supply Usable Water

IJSER

By –

Maruf Ahmed Sucorno

and

FaiyadZaimIshrak

Faujdarhat Cadet College

Bangladesh

Abstract

Our goal is to assess methods of purifying flowing water resources using feasible methods and available resources and be able to supply usable water free from metallic impurities as well as organic wastes and odor. Due to its economic importance, the **River Turag** is prone to contamination by industrial effluents of riverside manufactories. Our study deals with $\mathbf{p^H}$, **BOD, COD, DO** and **alkalinity** in the water source we have worked on. Effluents such as prominent heavy metals (e.g. **Chromium, Mercury, Lead, Cadmium, Nickel, Zinc, Silver, Copper, Iron, Manganese and Barium**) have been put under notice for removal. At the same time, **current-propelled water wheels** would be used to AERATE water of the body. The motion of the wheels would be used to generate power which shall be utilized in lifting water by a pump from the source. This water would go through dynamic filtration and purification procedure. "Because of maximum feasibility, heavy metals are mostly removed by CHEMICAL PRECIPITATION" (Heavy Metal Removal Investigation in Conventional Activated Sludge System, 2020). Moreover, we are reducing the BOD through aeration. P^H of the River Turag is around the standard value in a normal river. Thus, the issue has not been put under severe scrutiny as like the other facts. Furthermore, COD is removed by some of the best options to treat pulping wastewater using COAGULATION and FLOCCULATION processes. "The chemicals, e.g. $Al_2[SO_4]_3$, $FeCl_3$, $FeSO_4.7H_2O$, poly-$AlCl_3$, $Ca[OH]_2$ are to be used in this process"(CPCB Sewage Discharge Standards, 2017). Several experiments have been conducted to confirm the viability of this method. Through our experiments, we have come to realize that this would be a completely feasible method of supplying usable water to nearby localities as well as ensure biological activity in water sources.

Table of Contents

Abbreviations and Acronyms

GA → Group Analysis

BOD → Biological Oxygen Demand

COD → Chemical Oxygen Demand

DO → Dissolved Oxygen

TDS → Total Dissolved Solid

CPCB → Central Pollution Control Board

STP → Sewage Treatment Plant

Acknowledgements

Biography

Maruf Ahmed Sucorno
Class-XI
Faujdarhat Cadet College

Faiyad Zaim Ishrak
Class-XI
Faujdarhat Cadet College

Introduction

Bangladesh is the largest delta of the world and its topography is abundant of rivers and other dynamic water sources. We have observed due to mismanagement, one of the major rivers of our country, the Buriganga can be regarded as 'biologically dead'. In 1957, pollution levels in the River Thames was so bad that it was regarded the same. But by proper aeration and other measures, the river has thus been revived and its ecosystem has emerged. The River Turag flowing through Tongi near Dhaka of Bangladesh is another source prone to this sort of biodegradation. We have prepared our research targeting this river and thus plan to conduct aeration as well as ensure the biological environment of this water body. We plan to use shored Pelton Wheel model water turbines in the process and use them to generate electricity at the same time. This power would be used to lift the river water to the purifier for further chemical disintegration of heavy metals as well as other impurities from the water through GROUP ANALYSIS, separation of metallic nanoparticles by PERMANENT MAGNET and CARBON FILTRATION. In the River Turag, the presence of metals are as follows:

Element	Amount (g^{-1})
Chromium	178 µg
Nickel	155.4 µg
Iron	1367.9 µg
Lead	18.3 µg
Cadmium	0.8 µg
Zinc	194.1 µg
Copper	54.8 µg
Manganese	5501.6 µg

(Progressive Agriculture, 2016)

Several statistics of the River Turag are as follows:

Content	Existing Qty.	Standard Qty.
p^H	6.6 - 7.98	around 7.4
BOD	10 - 180 mg/L	(2 – 8) mg/L
COD	21 - 220 mg/L	(50 or less) mg/L
DO	0.11 - 6.8 mg/L	around 5.5 mg/L

(Study of the Seasonal Variations in Turag River Water Quality Parameters, 2012)

It has been noticed from studies that the color of the water of River Turag was **light** to **dark black** and emitted noxious smell due to the industrial effluents. The upstream water was slightly alkaline with **comparatively high** DO content while lower concentration of other parameters. The minimum and maximum values of various contents are as follows:

Content	Range
p^H	7.24 – 7.61
DO	1.22 – 3.66 ppm
BOD	(-2.44) – 0.86 ppm
TDS	239 – 1349 ppm

The continuous dumping of waste materials resulted in a marked increase in the concentration of metals in the river water varied in the order of,

Fe > Zn >Pb> Cu > Cd

(Effects of Solid Waste and Industrial Effluents on Water Quality of Turag River at Konabari Industrial Area, Gazipur, Bangladesh, 2012)

Based on the given statistics and studies, we have conducted our procedure to supply pure and potable water to the local communities. This is to be noted that the given quantities are results of dynamic experiments and studies conducted in correct order.

Materials and Methods

In implementation of this project, water turbines of **Pelton's Wheel Model** have been placed by the shores at specific distances in the river to allow river transportation. This is to allow aeration at a close proximity in the river and maintain the **BOD** and **DO** of the water in the region of the water to be lifted for purification. Furthermore, the water turbines would rotate by the river current and thus generate power- which would be used to run a pump that lifts water from the river to the **purifier**. The standard format of the energy produced from each of our installments where we consider the **efficiency of the wheel/turbine to be 33%** (n), **the density of water being 1000kg/m^3** (p), **the acceleration of gravity being 9.8m/s**(g), **depth of the water from surface should be (0.1) m**(h)and **the flow of water per second be considered 1 m^3/s** (Q).

Based on the given parameters, placing the values in the equation for the total generated power from a turbine, we get:

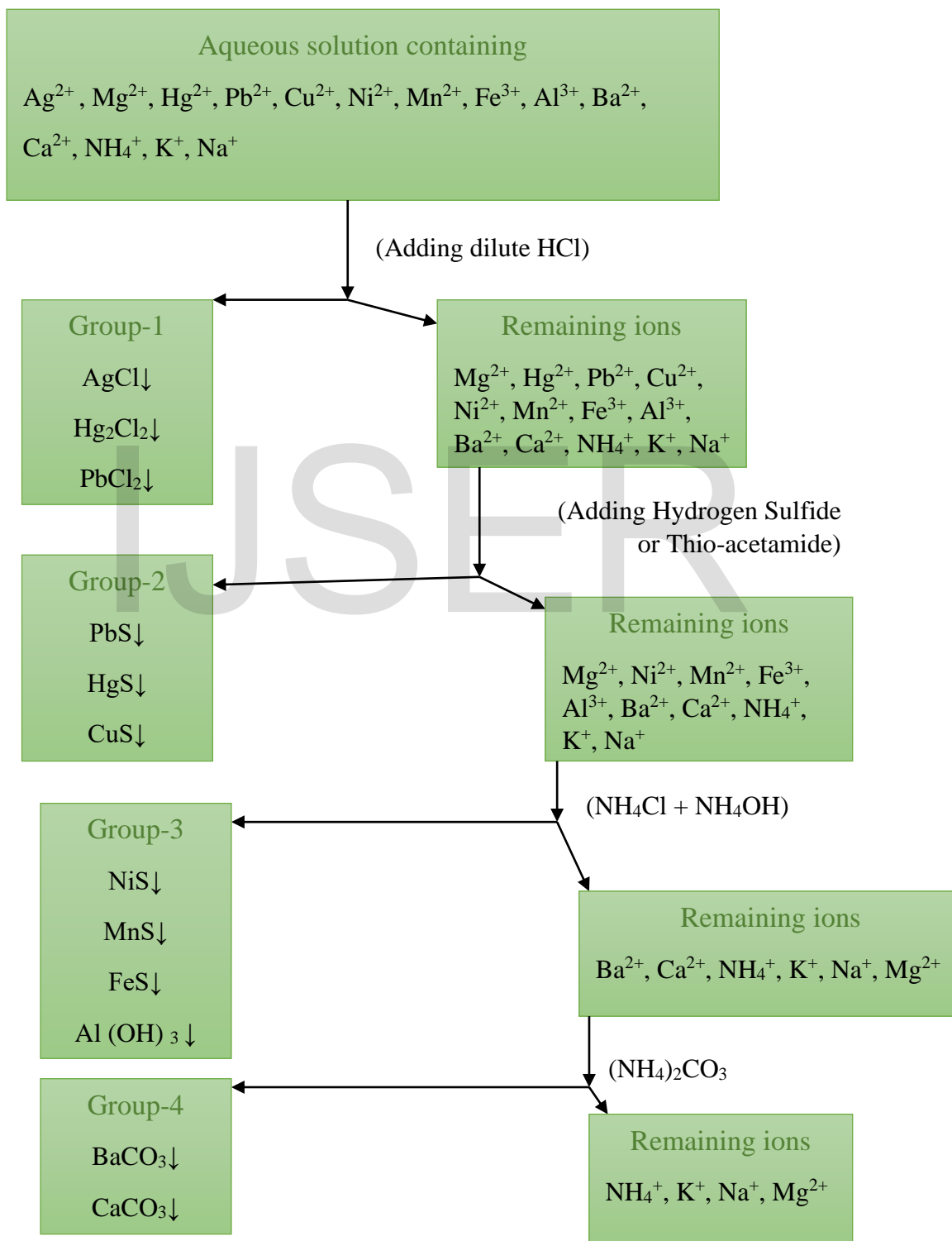**Generated Power (in 24 hrs) = nphgQ = 27 MWh**

This energy would be conducted and stored in batteries to be used by the pump to lift it for purification of the water simultaneously.

- It is to be noted that we have planned of placing a total of 30 such installments in uniform proximities for maintaining aeration of the total confluence point

At this point the water from the river would be lifted and supplied to the purifier. **In a whole day**, **per installment** would raise **80000 liters** of water to be purified and go through further procedure.

The water of the River Turag (near the industrial zone) contains several metals in dissolved form. At the initial phase, the water would go through a channel of **permanent magnets** which would separate **Nickel, Chromium and Iron in extent to nanoparticles.** Further separation is to be conducted by **chemical disintegration by forming precipitates of the metals**.

❖ Group separation in qualitative analysis

Aqueous solution containing

Ag^{2+}, Mg^{2+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Ni^{2+}, Mn^{2+}, Fe^{3+}, Al^{3+}, Ba^{2+}, Ca^{2+}, NH_4^+, K^+, Na^+

(Adding dilute HCl)

Group-1

$AgCl\downarrow$

$Hg_2Cl_2\downarrow$

$PbCl_2\downarrow$

Remaining ions

Mg^{2+}, Hg^{2+}, Pb^{2+}, Cu^{2+}, Ni^{2+}, Mn^{2+}, Fe^{3+}, Al^{3+}, Ba^{2+}, Ca^{2+}, NH_4^+, K^+, Na^+

(Adding Hydrogen Sulfide or Thio-acetamide)

Group-2

$PbS\downarrow$

$HgS\downarrow$

$CuS\downarrow$

Remaining ions

Mg^{2+}, Ni^{2+}, Mn^{2+}, Fe^{3+}, Al^{3+}, Ba^{2+}, Ca^{2+}, NH_4^+, K^+, Na^+

$(NH_4Cl + NH_4OH)$

Group-3

$NiS\downarrow$

$MnS\downarrow$

$FeS\downarrow$

$Al(OH)_3\downarrow$

Remaining ions

Ba^{2+}, Ca^{2+}, NH_4^+, K^+, Na^+, Mg^{2+}

$(NH_4)_2CO_3$

Group-4

$BaCO_3\downarrow$

$CaCO_3\downarrow$

Remaining ions

NH_4^+, K^+, Na^+, Mg^{2+}

To remove **COD, alkalinity** and **other heavy metals** we need some specific chemicals in some specific quantities. The ratios of the chemicals to that of the solution is **1.5 ml to 5 ml**, which stands **3:10** in ratio.

The chemicals with their quantities and approximate values are as follows:

*For purification of 50 L of water

| Solutions	Chemicals	Amount	Cost in BDT
COD	$Al_2[SO_4]_3$	400 g	4
COD	$FeCl_3$	350 g	17
COD	$FeSO_4.7H_2O$	300 g	11
COD	$Poly\text{-}AlCl_3$	500 g	7
COD	$Ca[OH]_2$	700 g	5
Zn	NaOH	500 g	12
GA and Cd	H_2S	1250 ml	730
GA and Cd	$[NH_4]_2CO_3$	2000 g	96
GA	NH_4Cl	2000 g	43
GA	HCl	2000 g	15
GA	NH_4OH	2500 g	29
	Total======➜	12500 g	969

(Alibaba, 2020)

This is to be noted that:
- Iron is ferromagnetic; thus, it has strong magnetic attraction
- Nickel is ferromagnetic; thus, it has strong magnetic attraction
- Chromium is paramagnetic and therefore has magnetic attraction

❖ Permutit process

This is the process where hard water containing Ca^{2+} is filtered through a natural sand called **Zeolite**. **Calogen** is a trademark of complex salt, **Sodium hexametaphosphate** $(NaPO_3)_6$. Calogen gives a complex anion.

Sodium Aluminum Silicate/ Zeolite ➜ **$Na_2Al_2Si_2O_8$** In our process, to soften **50 L water** we need **3 kg permutit**, which only costs **75 BDT**.
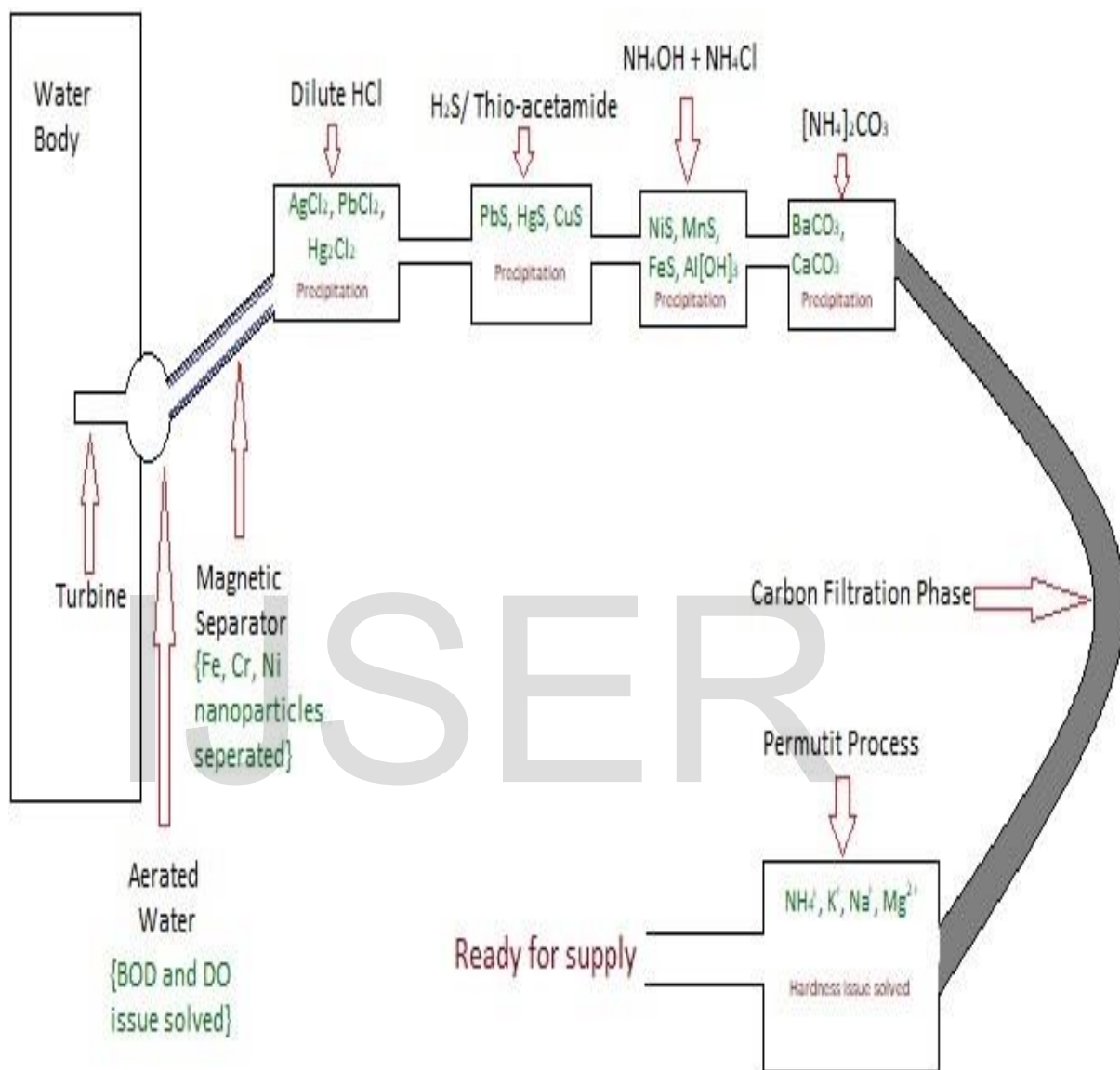
Result

The results of our procedures are illustrated through the given points:

- In our process, at the initial stage water is being aerated using water turbines. **AERATION is the process, through which air is circulated through and dissolved with liquid,** thus maintaining the amount of **DO** and **BOD** of the water.
- Power generated from the rotation of the turbines would be stored and then used to run a pump that would raise water from the water source to the **purifier**
- The water would go through simultaneous purification procedure, which are as follows:
  - Magnetic separation of **Fe, Ni** and **Cr** nanoparticles
  - Reduction of **COD** through **coagulation and flocculation** processes
  - Addition of **dilute HCl** to settle **Silver Chloride, Lead Chloride and Mercuric Chloride**
  - Addition of **Hydrogen Sulfide** or **Thio-acetamide** to settle **Lead Sulfide, Mercuric Sulfide, Copper Sulfide**
  - Addition of the mixture of **Ammonium Chloride** and **Ammonium Hydroxide** to settle **Nickel Sulfide, Manganese Sulfide, Ferrous Sulfide and Aluminum Hydroxide**
  - Addition of **Diamine Carbonate** to settle **Barium Carbonate and Calcium Carbonate**

- The water which has thus been purified from most heavy metallic particles will now go through **adsorption process** through a filter pipe consisting of **charcoal,** the water will thus be pure from **volatile organic compounds, taste and odor**
- The hardness of this water will now be removed by **permutit process** using **Sodium Aluminum Silicate/ Zeolite**
- The water is thus now ready to be supplied

Discussion

The surveys of the heavy metals are mostly done in the **confluence point** of the **River Turag**. Therefore, our studies and procedures are based on the water specimen of the zone where the metallic as well as organic impurities are at its extreme. So, if we shift to the rural sides where pollution levels are comparatively low, then we would be able to purify the water at **minimum cost**.
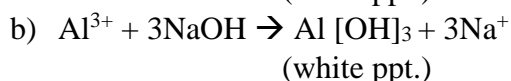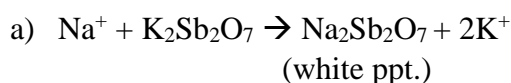
As for example, Cadmium exists at **0.8 μg/g** in the **industrial zones**. Cadmium being an **uncommon content** in natural sources of water, it is evident that the rates of this chemical is **far less** in the rural areas. For removal of Cadmium we need to use **plentiful** amounts of **Hydrogen Sulfide or Thio-acetamide** which costs a lot. This cost will be **drastically reduced** if the processes are conducted in the **rural areas**.

Moreover, we plan on conducting **aeration** of the river. There are reports of many projects throughout our country where aeration is being conducted to **ensure the biological standards** of the water body for pisciculture. They require **electricity run aerators** in this process. The reason, for which our aeration is different to that, is that this process **requires no fuel cost**. Because our aerators are rather turbines or water wheels which **run through the current or flow of the river**. It is moreover generating **enough power to run a water pump** which would be used to raise the water for purification in the latter phases.

Our study and research focus on purifying water to a drinkable extent. So, if we plan on supplying it in a limit where it would be only **enough pure to be used**, lesser chemicals would be needed to be used which thus results in lesser cost.

These are the basic format of chemical reactions which occur throughout our **group analysis**, which we have confirmed from several **reference books**. And for further confirmation, we have conducted the reactions through experiments in the laboratory of our institution.
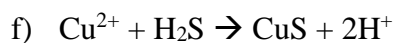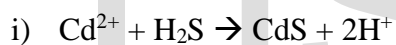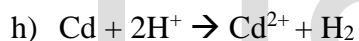
The reactions are as follows:

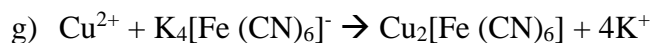a) $Na^+ + K_2Sb_2O_7 \rightarrow Na_2Sb_2O_7 + 2K^+$
   (white ppt.)

b) $Al^{3+} + 3NaOH \rightarrow Al[OH]_3 + 3Na^+$
   (white ppt.)

c) $CuSO_4 + NH_4OH \rightarrow CuSO_4.Cu[OH]_2 + [NH_4]_2SO_4$

(light blue ppt.)

d) $CuSO_4.Cu[OH]_2 + NH_4OH + [NH_4]_2SO_4 \rightarrow [Cu(NH_3)_4]SO_4 + H_2O$

(deep blue ppt.)

e) $Pb^{2+} + 2KI \rightarrow PbI_2 + 2K^+$

(yellow ppt.)

f) $Cu^{2+} + H_2S \rightarrow CuS + 2H^+$

(black ppt.)

g) $Cu^{2+} + K_4[Fe(CN)_6]^- \rightarrow Cu_2[Fe(CN)_6] + 4K^+$

h) $Cd + 2H^+ \rightarrow Cd^{2+} + H_2$

i) $Cd^{2+} + H_2S \rightarrow CdS + 2H^+$

(yellow ppt.)

j) $Cd^{2+} + 2NH_3 + H_2O \rightleftharpoons Cd[OH]_2 + 2NH_4^+$

(white ppt.)

k) $Zn^{2+} + H_2S \rightarrow ZnS + 2H^+$

(white ppt.)

l) $Zn^{2+} + NaOH \rightarrow Zn[OH]_2 + Na^+$

(white ppt.)

m) $K_2HgI_4 \rightarrow KI + HgI_2$

n) $2HgI_2 \rightarrow Hg_2I_4$

o) $NH_3 + Hg_2I_4 \rightarrow NH_2[Hg_2I_3] + NH_4^+$
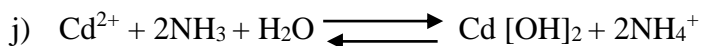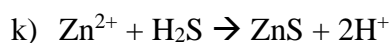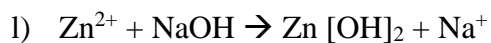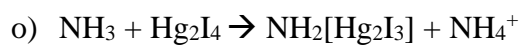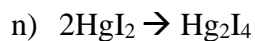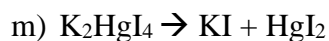
(violet ppt.)

Conclusion

So, this we hope that the project by considering its feasibility and validity let it be implemented if the opportunity is obtained. This project may as well serve as an alternative to today's costly water management procedures. Thus, this system would also bring a revolution in this field if put to use, contributing to the global water crisis greatly at the same time.

References

- (CPCB Sewage Discharge Standards, 2017)

- (Heavy Metal Removal Investigation in Conventional Activated Sludge System, 2020)

- (Progressive Agriculture, 2016)

- (Effects of Solid Waste and Industrial Effluents on Water Quality of Turag River at Konabari Industrial Area, Gazipur, Bangladesh, 2012)

- (Alibaba, 2020)

- (Study of the Seasonal Variations in Turag River Water Quality Parameters, 2012)