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# Removal of Iron and Chromium from Effluent Water of Steel Plant using *Syzygium Cumini* Seed

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## Abstract

In the current scenario health of people has been greatly incriminated due to heavy metal defilement. Modernization and industrial enterprise are the major cause for the incorporation of heavy metals in the environment. The most precarious heavy metals which are found to impinge water bodies are chromium, mercury, lead, cadmium, and iron etc. Most of the treatment techniques are found to be risk due to the production of secondary pollutant. Such problem can be rectified by the use of natural adsorbents which will reduce the secondary pollutant to large extent. The most efficacious and economic process for the removal of toxic heavy metal is biosorption. Present investigation aims to analyse the effluent water generated from steel plant and remove heavy metals like iron and chromium from it using *Syzigium Cumini* seed powder as adsorbent.

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**Keywords:** *Syzygium Cumini*, Adsorbent, Heavy metals, Effluent water, Secondary pollutant, Biosorption.

## 1. Introduction

An emerging threat in today's context is environmental pollution. [1] Heavy metals are toxic pollutant, which are introduced in to the ecosystem due to industrial technologies. [2, 3] Heavy metals such as iron, chromium, lead, mercury and copper etc. in water bodies cause critical health issues, which are found to be non-biodegradable and carcinogenic [4-9].

Iron and steel industry is one of the most important and vital industry of the present and future. Effluent water from the steel mill contains a high concentration of heavy metals like chromium and iron. Exposure to excess iron doses result in iron toxicity such as diarrhoea, biphasic shock, anorexia, hypothermia, metabolic acidosis and even death [10, 11], whereas chromium is known to cause liver damage, mutagenic changes, neurological disorders etc. [12] US EPA (2014) termed Chromium as potential carcinogen. Hence, it is necessary to remediate chromium and iron contaminated sites [13].

The metal binding capacities of biological materials have made attention for the removal toxic heavy metals from effluent water using adsorption technique. [14-20] This technique is found to be effective for the removal of iron and chromium from effluent water. [21] The natural method is found to be more advantageous due to its highly efficient, cost-effective toxic metal removal in an eco-friendly manner. The main objective of the present investigation is to analyse the effluent water generated from steel plants and remove the toxic metallic pollutants like iron and chromium using dried *Syzygium Cumini* seed powder as adsorbent.

## 2. Materials & Methods

### 2.1. Area of Study

The area under study lies between Kavarapettai and Gummidipoondi of Thiruvallur district, covers an area of about 550 Km and monthly mean temperature of 28°C to 45°C.

## 2.2. Sample Collection

The effluent water from steel plants were collected in plastic containers, labelled and transported to the laboratory for analysis.

## 2.3. Water Quality Parameters

Effluent water was analysed for Conductivity, $p^H$, Residual free chlorine, Hardness, Alkalinity, Iron, Chromium, Organic matter, "TDS", "TSS", "DO", "BOD" and "COD".

## 2.4. Materials

### 2.4.1 Instruments

$p^H$ meter, Conductivity meter, Magnetic stirrer, Spectrophotometer and Hot air oven.

### 2.4.2 Apparatus required

Standard flask, Beaker, Measuring jar, Nessler's tube, Burette, Pipette, Conical flask, BOD Incubator, BOD bottles and COD Digester.

### 2.4.3. Chemicals Required

Buffer solutions, Potassium chloride, Hexamethylenetetramine, Hydrazine sulphate, Chlorotex reagent, EBT, EDTA etc.

## 2.5. Methods

Effluent water from steel industries were treated by stirring 1000ml of the sample water with 1g of dried *Syzygium Cumini* seed powder for an hour, using magnetic stirrer at room temperature, filtered and subjected to water quality analysis.

Conductivity, $p^H$, turbidity, residual free chlorine, hardness, iron and chromium content were determined by Electrometric method, Probe and meter, Nephelometric, Chlorotex, EDTA and Spectrometric methods respectively.

BOD was determined by incubating the sample at a specified temperature for 5 days

$$\text{Biochemical Oxygen Demand} = (D1\text{-}D2) - (C1\text{-}C2)\ F / P$$

Where, D1 = Initial dissolved oxygen content of the diluted sample

D2 = Dissolved oxygen content of the diluted sample after incubation

C1 = Initial dissolved oxygen content of the seeded diluted water.

C2 = Dissolved oxygen content of the seeded diluted sample after incubation

P = Decimal fraction of the sample used.

COD of the water samples was determined using $K_2Cr_2O_7$/ $H_2SO_4$ as the oxidizing agent.

## 3. Results & Discussion

### 3.1 Results

**Table-1**
**Industrial Waste Water Quality Analysis Report**

| Parameter | EFW1 | | EFW2 | | SDTF | | |
|---|---|---|---|---|---|---|---|
| | **BT** | **AT** | **BT** | **AT** | **ISW** | **PS** | **OLI** |
| $p^H$ | 7.4 | 5.6 | 8.3 | 6.9 | 5.5-9 | 5.5-9 | 5.5-9 |
| Electrical Conductivity (μs) | 6038 | 7956 | 4017 | 4090 | 1000 | 1000 | 1000 |
| Turbidity (NTU) | 5.6 | 12.1 | 2.1 | 5.0 | 1-5 | 1-5 | 1-5 |
| Residual Free Chlorine (ppm) | Nil | Nil | Nil | Nil | 0.2 | 0.2 | 0.2 |
| Total Hardness (ppm) | 754 | 760 | 322 | 380 | 120-170 | 120-170 | 120-170 |
| Ca-Hardness (ppm) | 500 | 460 | 200 | 180 | 60-180 | 60-180 | 60-120 |
| Mg-Hardness(ppm) | 254 | 300 | 122 | 200 | 10-100 | 10-100 | 10-100 |
| P-Alkalinity | 0 | 0 | 26 | 0 | 20-200 | 20-200 | 20-200 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (ppm) | | | | | | | |
| M-Alkalinity (ppm) | 62 | 50 | 202 | 80 | - | - | - |
| Chloride (ppm) | 2.6 | 2.5 | 1.4 | 1.2 | 250 | 250 | 250 |
| Chromium (ppm) | 10.2 | 2 | 9.6 | 1.5 | 0.1 | 0.1 | 0.1 |
| Iron (ppm) | 79 | 30 | 590 | 139 | 0.3 | 0.3 | 0.3 |
| Organic Matter (ppm) | 0 | 0 | 0 | 0 | 2 | 2 | 2 |
| TDS (ppm) | 6 | 2 | 8 | 3 | 500 | 500 | 500 |
| TSS (ppm) | 0.8 | 2.6 | 0.4 | 1.8 | 25 | 25 | 25 |
| DO (ppm) | 3 | 5 | 4 | 6 | 6.5-8 | 6.5-8 | 6.5-8 |
| CPD (ppm) | 16 | Nil | 12 | - | 250 | 250 | 250 |
| BOD (ppm) | 6 | 1.5 | 4 | Nil | 30 | 30 | 30 |

SG-*Syzigiumcumini*; EFW1-Kamatchi Steel plant; EFW2- Hi Tech Carbon Pvt. Ltd.;

AT- After Treatment; BT- Before Treatment

Effluents from two different steel plants near Gummidipoondi area were collected and analysed for various water quality parameters. A cost effective and eco-friendly way of treating the waste water was followed using bio sorbent (i.e.) *Syzygium Cumini* seeds and the treated water was again subjected to water quality analysis to identify the extent of removal of impurities. The analysed parameter with standard specifications is tabulated in Table 1.

### 3.2. Discussion

#### 3.2.1. Acidity & Alkalinity

Concentration of hydrogen ions in water can be measured in terms of $p^H$. [22] Acceptable range of $p^H$ suggested by ISI, WHO & IS is 6.5 – 8.5. $p^H$ of the investigated sample ranges from 7.4-8.3 (Fig. 1). But after treatment it was able to observe a change in medium from alkaline to acidic. It is interesting to note that acidic constituents of

*Syzygium Cumini* seeds neutralizes the basic constituents of waste water and making it as acidic.

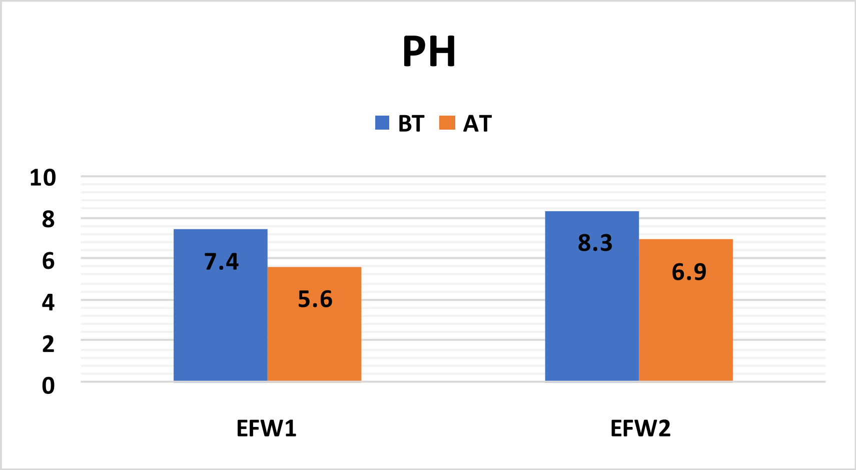


**Fig. 1: pH of the EFW1 & EFW2**

### 3.2.2. Electrical Conuctivity

Electrical conductivity gives a measure of salt concentration in water. The increase in conductivity of the investigated samples on treating with *Syzygium Cumini* seed is due to the presence of calcium and magnesium metal ions in *Syzygium Cumini* fruit and seed which has increased the conductivity of the investigated samples. This can also be accounted to be due to the change of medium from basic to acidic.

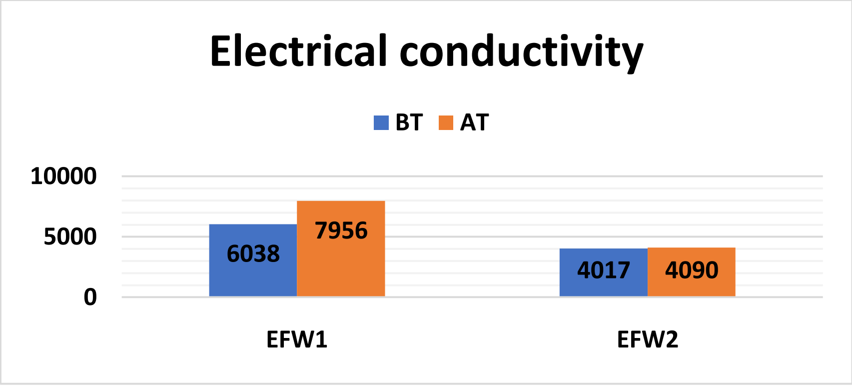


**Fig. 2: Electrical conductivity of the EFW1 & EFW2**

### 3.2.3. Turbidity

Particulate waste generated by industrial processes affect transparency of effluent water. Turbidity causes biological contamination and affect effectiveness of chlorination (Fig. 3) [23].

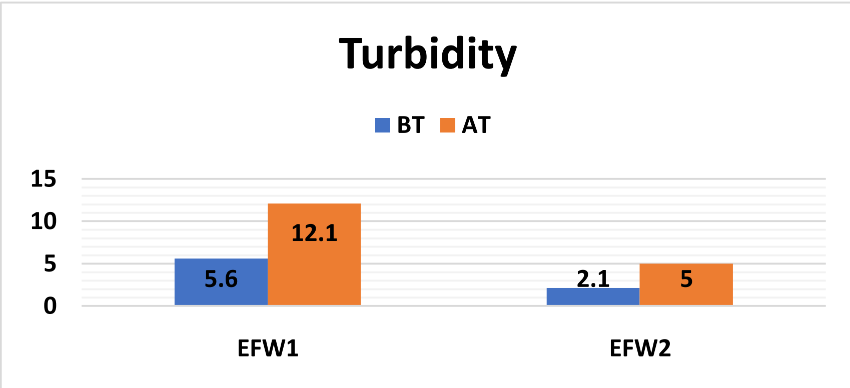


**Fig. 3: Turbidity of the EFW1 & EFW2**

### 3.2.4. Hardness

Calcium and magnesium salt content in water can be measured in terms of hardness. Hardness of the investigated samples was found to be in the range of 322-754ppm (Figs.4-6). But treatment of water using *Syzygium Cumini* seed powder causes an increase in hardness. This is accounted to be due to the release of more magnesium ions in water, which is formed by the reaction of compounds of magnesium with active constituents of *Syzygium Cumini* seeds. This fact is also observed from an increase in magnesium hardness [24].

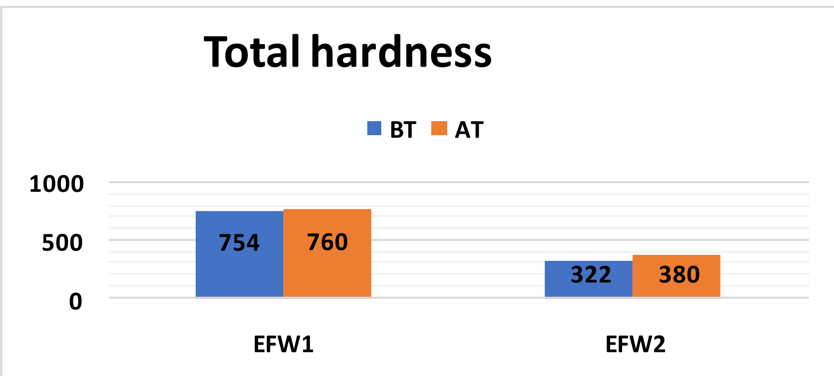


**Fig. 4: Total hardness of the EFW1 & EFW2**

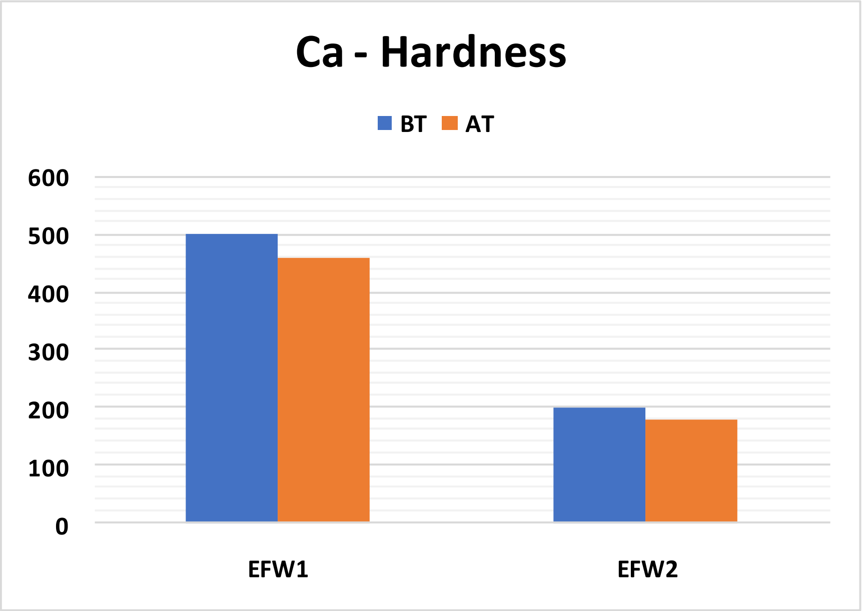


**Fig. 5: Ca-Hardness of the EFW1 & EFW2**

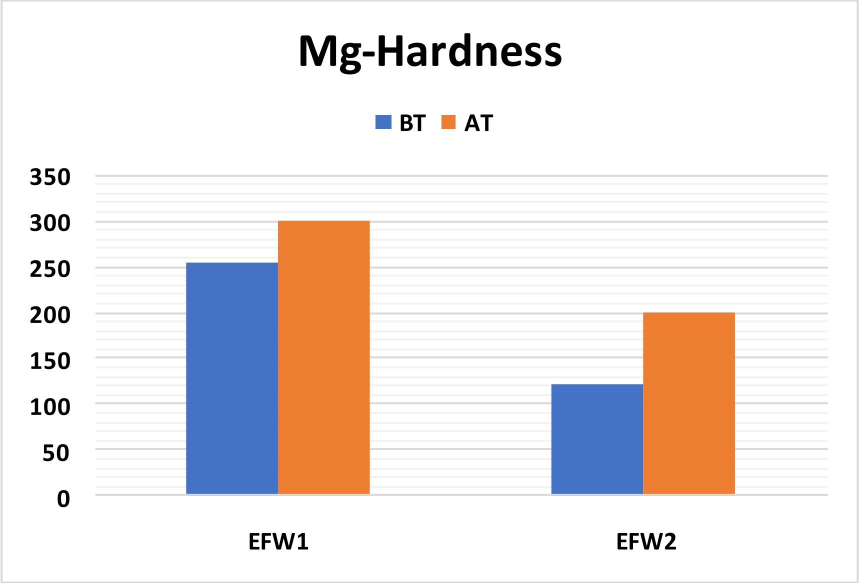


**Fig. 6: Mg-Hardness of the EFW1 & EFW2**

### 3.2.5. Alkalinity

No phenolphthalein alkalinity was observed in EFW1 whereas a small value of 26ppm was observed in EFW2. But after treating the waste water with *Syzygium Cumini* seeds, P-alkalinity is completely removed (Fig 7).

Methyl orange alkalinity of the investigated sample was found to be in the range of 62-202ppm. But an extreme reduction in M-alkalinity in the range of 50-80ppm was observed after treating with *Syzygium Cumini* seed powder, suggesting the best coagulating and adsorbent character of *Syzygium Cumini* seed (Fig. 8).

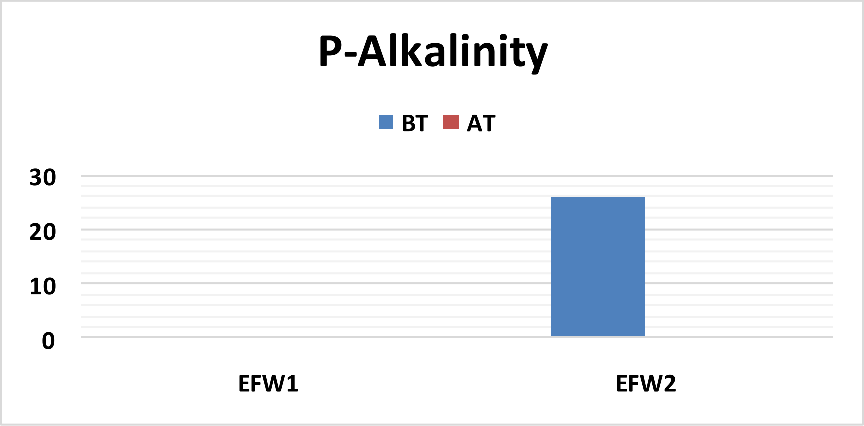


**Fig. 7: P-Alkalinity of the EFW1 & EFW2**

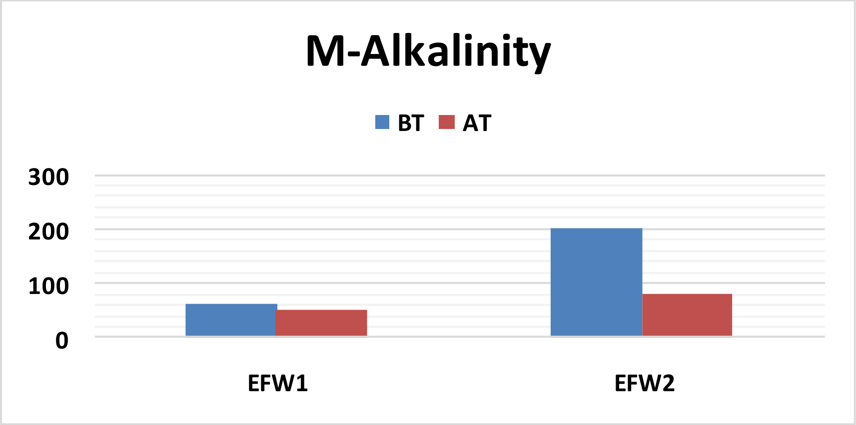


**Fig. 8: M-Alkalinity of the EFW1 & EFW2**

### 3.2.6. Chloride

Excess chloride content in water causes laxative effect. The investigated samples were found to have chloride content in the range of 1.4-1.6ppm. But a reduction in chloride content was observed after treatment with the sorbent *Syzygium Cumini* seed powder (Fig. 9).

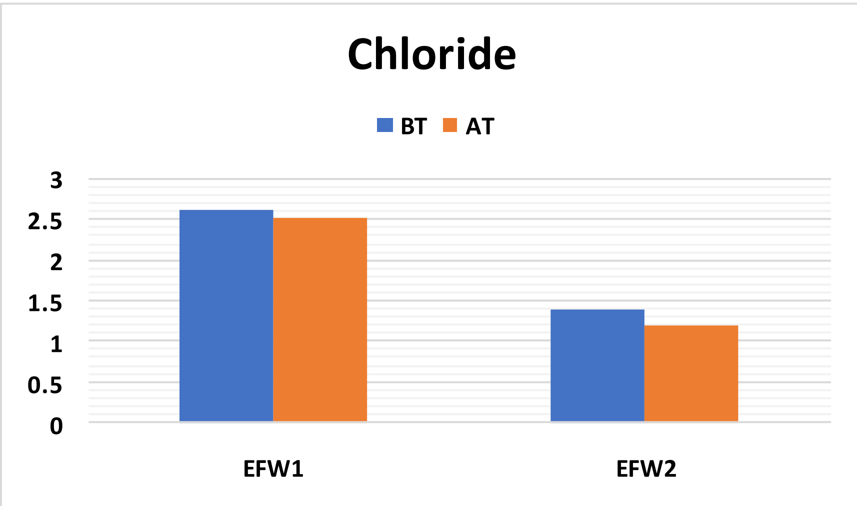


**Fig. 9: Chloride content present in the EFW1 & EFW2**

### 3.2.7. Chromium

Chromium contamination in water creates a lot of health hazard such as respiratory cancer, kidney damage, asthma, liver damage, nose irritation and damage etc. *Syzygium Cumini* seed powder is acting as a very good adsorbent for the removal of Chromium from water. This is accounted to be due to the fact that addition of *Syzygium Cumini* seed powder makes the medium(water) acidic, which is favourable for the adsorption of chromium from water. Hence an extreme reduction in the chromium content was observed after treating effluent water with *Syzygium Cumini* seed powder and hence it can be advised for the complete removal of chromium from effluent water by increasing the acidity of medium(Fig. 10).

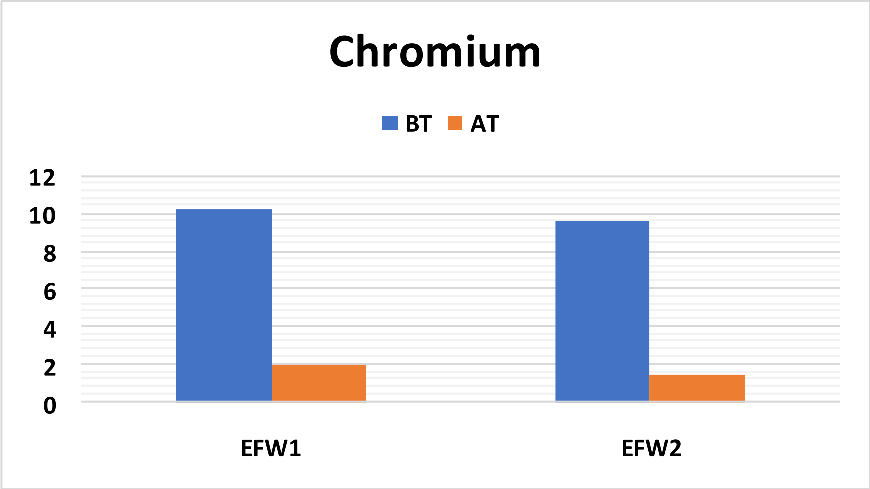


**Fig. 10: Chromium content present in the EFW1 & EFW2**

### 3.2.8. Iron

Iron in water does not cause danger to human health or environment but gives rust colour, metallic taste and can stain linen and food industry products. But molecular studies show that iron toxicity causes toxic effect on intracellular organelles, particularity mitochondria and lysosomes. Excess iron intake can cause cellular damage and alteration of genetic structure of phenotype (Fig. 11).

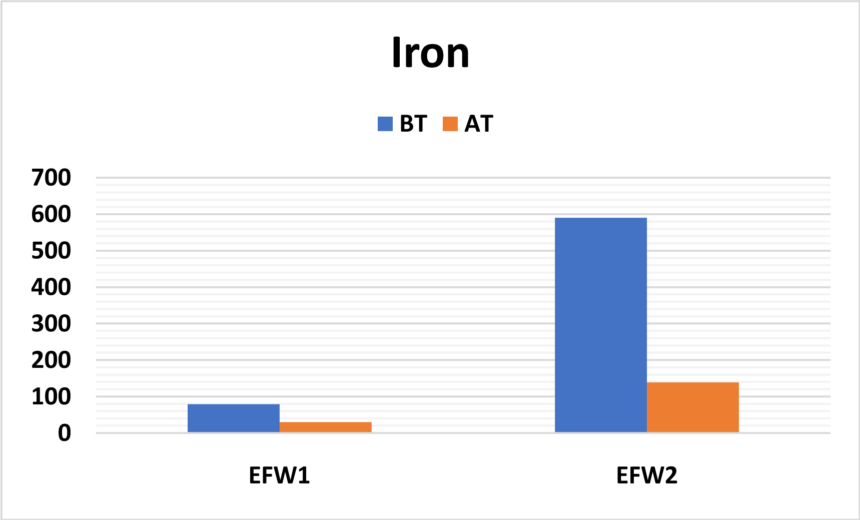


**Fig. 11: Iron content present in the EFW1 & EFW2**

The investigated samples were found to have iron content in the range of 79–590ppm before treatment where as an extreme reduction of iron content in the order to 30 to 139ppm was observed after treatment, which is indicating an excellent adsorbent character of *Syzygium Cumini* seeds and better results were observed in the removal of iron compared to other impurities. Hence *Syzygium Cumini* seed may be used for the complete removal of iron from water.

### 3.2.9 Total Dissolved Solids

Presence of Calcium, magnesium, sodium, potassium etc. in water acts as its salinity indicator. Investigated samples were found to have very low TDS, which is in the range of 6-8ppm (Fig. 12). A reduction in the TDS was observed after treating with *Syzygium Cumini* seed powder.

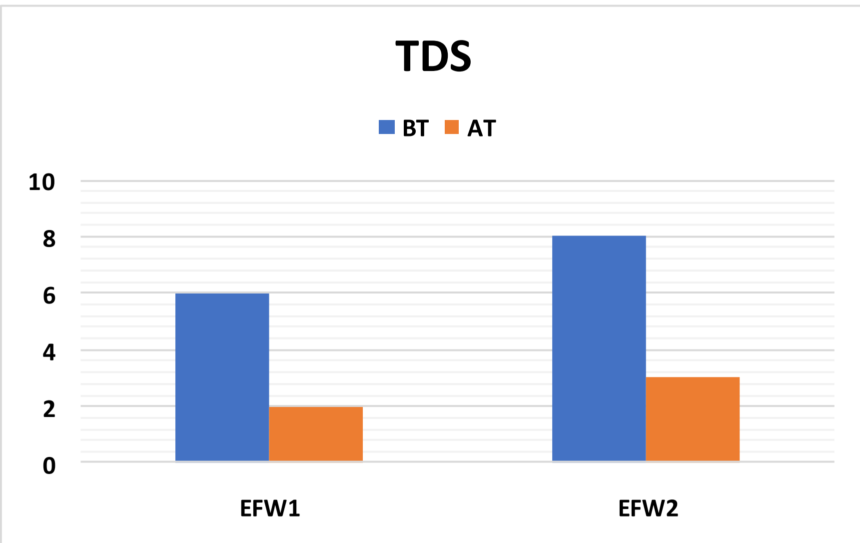


**Fig. 12: TDS present in the EFW1 & EFW2**

### 3.2.10. Dissolved Oxygen

Organic pollutants in water reduces its dissolved oxygen content which affect aquatic life.

A very low range of DO in the range of 3- 4 ppm was observed in the effluent collected from steel plant but these values are improved to some extent in the range of 5.0 to 6.0ppm after treating with *Syzygium Cumini* seed powder (Fig. 13).

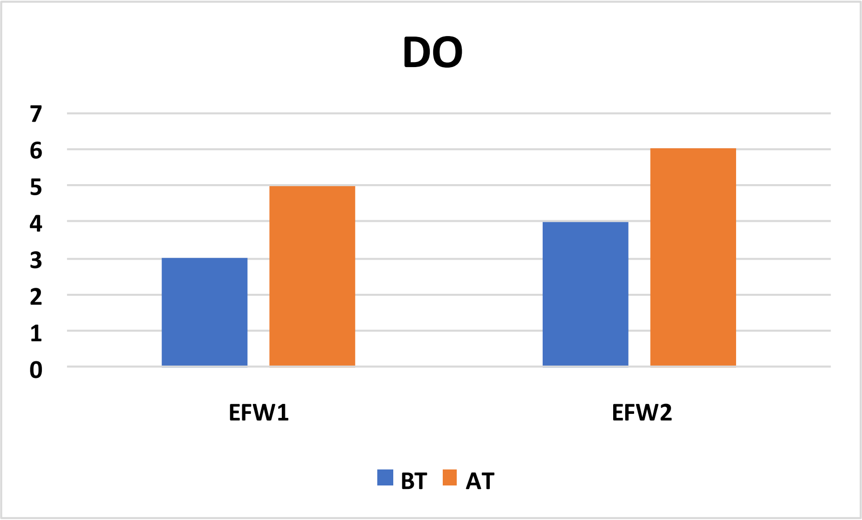


**Fig. 13: DO ofthe EFW1 & EFW2**

### 3.2.11. Biological Oxygen Demand

Degradable organic waste in water is measured in terms of BOD. Investigated samples were found to have BOD values in the range of 4-6ppm, but after treatment using *Syzygium Cumini* seeds organic wastes are completely removed, indicating an excellent coagulating nature of *Syzygium Cumini* seeds (Fig. 14).

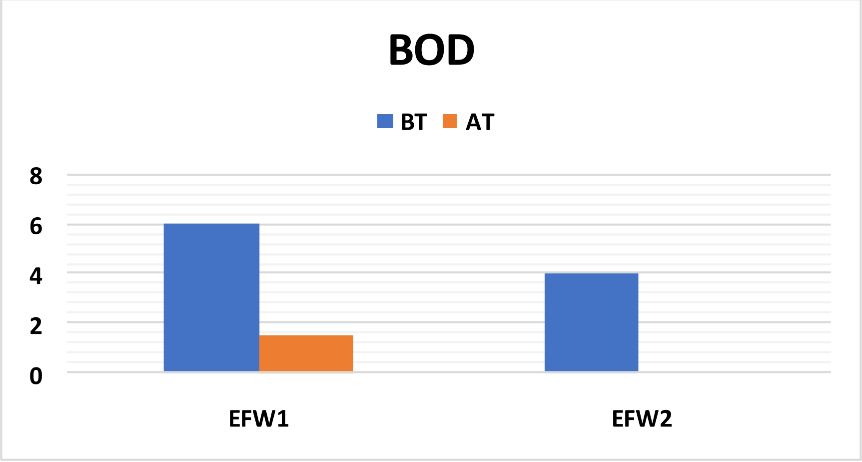


**Fig. 14: BODof the EFW1 & EFW2**

### 3.2.12. Chemical Oxygen Demand

Amount of toxicity, non-biodegradable and chemically oxidizable waste present in effluent water can be measured using COD value. [25-30] The investigated samples were found to have COD value in the range of 12-16 ppm, which indicates the presence of chemically oxidizable impurity. But an extreme reduction in the COD values were observed after treatment with *Syzygium Cumini* seed powder, indicating an excellent adsorption power of the selected adsorbent (Fig. 15).

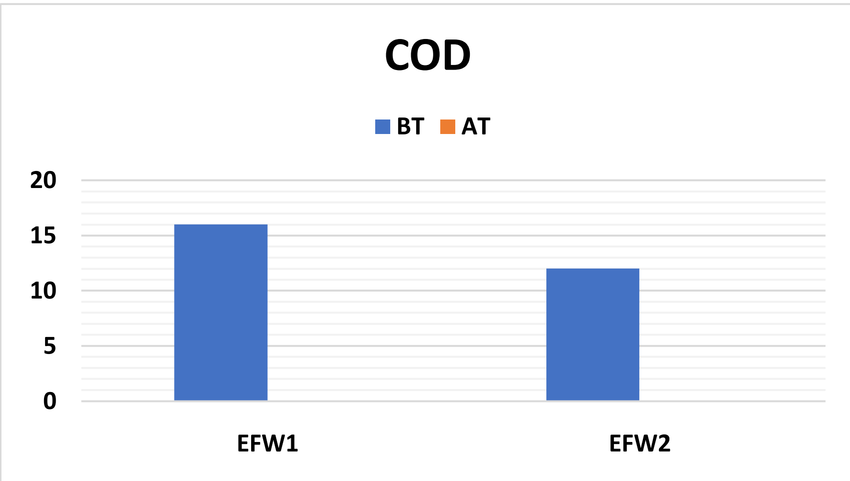


**Fig. 15: Chloride content present in the EFW1 & EFW2**

## 4. Conclusion

Effluent water of two different steel plants from Gummidipoondi, Thiruvallur district were collected and its pollutants were analysed by measuring electrical conductivity, $p^H$, Turbidity, FRC, TDS, TSS, hardness, alkalinity, chloride, chromium, iron, organic matter, DO, BOD, & COD using standard methods. Conventional technologies are found to be cost prohibitive and having inadequate efficiencies for the removal of heavy metal ion. Metal binding capacity of biological materials directed attention for the removal of toxic heavy metals from effluent water. In the present investigation *Syzygium Cumini* seed was dried, pulverised and treated the waste water collected from steel plants using magnetic stirrer for 1 hour. The treated water was analysed for various water quality parameters using standard methods. After treatment it was found that almost all the impurities were removed and also investigated that *Syzygium Cumini* can be used for the removal of iron, chromium, BOD and COD to maximum extent because of its excellent metal binding capability than other bio sorbents.

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