PERFORMANCE ASSESSMENT OF DIFFERENT TYPES OF EFFLUENT TREATMENT PLANT PROCESSES

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ABSTRACT

An effluent treatment plant (ETP) is a wastewater treatment process used in industries for treating effluent. Industrial effluents are major sources of water pollution, because different toxic chemicals and other contaminants present in the wastewater undergo chemical and biological changes, consume dissolved oxygen, destroy aquatic life, and pose a threat to human health. The rising trend of economic development in Bangladesh is triggering industrial growth along the banks of the Upper Meghna River and its adjoining areas due to land availability and navigation facilities. ETP establishment is mandatory for red and orange category industries according to Environment Conservation Rules (ECR), 2023. Different types of ETPs have been constructed for the treatment of industrial waste which follow mainly three major types of treatment processes: Physical, Chemical and Biological. The establishment of ETPs and their design depend on the quantity and quality of the incoming effluent, budget allocation for construction, operation and maintenance, and the land availability. Industrial database in industrial areas in Narayanganj and Narsingdi districts has been collected from the Department of Environment's (DoE) central and district level offices, which includes ETP capacity, type of ETP process, inlet and effluent quality data, etc. The performance of ETP has been analysed covering pollution parameters such as pH, biological oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solids (TDS) in this study for dyeing and other industries like textile, papermill, etc. It is observed from the ETPs effluent water quality data of dyeing industries that about 90% to 100% of ETPs complied in terms of pH level, 61% to 80% in case of BOD level, 93% to 100% in case of COD level and 82% to 95% in case of TDS level, compared with the environmental quality standards (EQS) values in ECR (2023). For other types of industries, the performance complied with is about 95% to 100% in case of pH level, 66% to 69% in case of BOD, 80% to 88% in case of COD and 75% to 93% in case of TDS. But, in some cases, TDS concentration in the effluent increased compared to the influent of ETPs. For controlling industrial pollution, the performance of the existing ETPs needs to be upgraded by more quality control and/or introducing more advanced treatment processes.

Keywords: Effluent, ETP, Biochemical, Physio-chemical, Biological, Wastewater Treatment

1. INTRODUCTION

1.1 Background

Industrial development and its contribution to Bangladesh's economy has been gradually and consistently expanding over the past few years. Bangladesh Bureau of Statistics (BBS) estimated that the contribution of the broad industry sector to GDP is about 34.23% in the 2022-23 fiscal year (FY) which was only 24.05% in FY 2006-07. Bangladesh is the 2nd largest economy in South Asia and the 34th largest in the world in 2022 (CEBR, 2022). But the industrial development is growing fast with the price of environmental degradation. According to the Wolf et al. (2022), Bangladesh stands in 177th position among 180 countries in terms of Environmental Performance Index (EPI), which shows the poor performance of Bangladesh in overall environmental management.

About, 30-40% of the country's total water consumption is used in enthralling, blistering and dyeing operations of industries. The extent of enthralling, blistering and dyeing processes resulted in huge volumes of liquid waste being discharged into the surrounding rivers, canals and lowlands. Industrial effluents are a major source of water pollution because different toxic chemicals and other contaminants present in the wastewater undergo chemical and biological changes, consume dissolved oxygen, destroy aquatic life, and pose a threat to human health. Dyeing, leather, sugar, pulp, and paper industries are the major contributors to water pollution. To reduce water pollution, treatment of the effluent quality is essential.

The Government of Bangladesh is pushing industries to install Effluent Treatment Plants (ETPs) in red and orange category industries to protect the environment from pollution. The Department of Environment (DoE) has a mandate to support the proper monitoring and management of the effluents and enforcement of the law. The Environment Conservation Act (ECA, 1995) provides that water polluting industries must install Effluent Treatment Plants (ETP) to treat their wastewater to achieve standards as per ECR before releasing it into the receiving environment.

An ETP is used in industries like pharmaceuticals, textiles, and chemicals to treat their effluent water where relatively higher water contamination is a possibility. Organic and inorganic matter, heavy metals, oil & grease, suspended and dissolved particles, and other contaminants can be treated in the wastewater treatment process of an ETP plant. DoE officials have a mandate to assess performance of ETPs in the existing industries.

1.2 ETP Treatment Process

There are mainly three major types of treatment processes in an ETP plant which are: Physical, Chemical and Biological. The design of an ETP varies depending on the quantity and quality of the effluent, budget allocation for construction, operation and maintenance, and amount of land available. There are generally four levels of treatment, as given below:

- Preliminary Treatment/Pretreatment: Removal of large solids such as rags, sticks, grit and grease that may result in damage to equipment or operational problems (Physical process).
- Primary Treatment: Removal of floating and settleable materials, i.e., suspended solids and organic matter. Sludge that settles on the bottom of the primary clarifier is pumped out and subject for sludge processing (Physical and Chemical processes).
- Secondary Treatment: Removal of biodegradable organic matter and suspended solids. It involves most preferred biological aerobic process called "Activated Sludge Process" which effectively removes most of the organic matter (Biological and Chemical processes); and
- Tertiary/Advanced Treatment: Takes out residual suspended solids / dissolved solids and improves the quality of treated water to comply with discharge standards. It also involves removing undesirable microbes through disinfection. (Physical, Chemical and Biological processes).

To improve effluent quality before discharging to the natural system, it being treated in ETPs. The ETPs have been constructed in the industries in Narayanganj and Narsingdi area in combination of above-described processes which follow the operation process as discuss below:

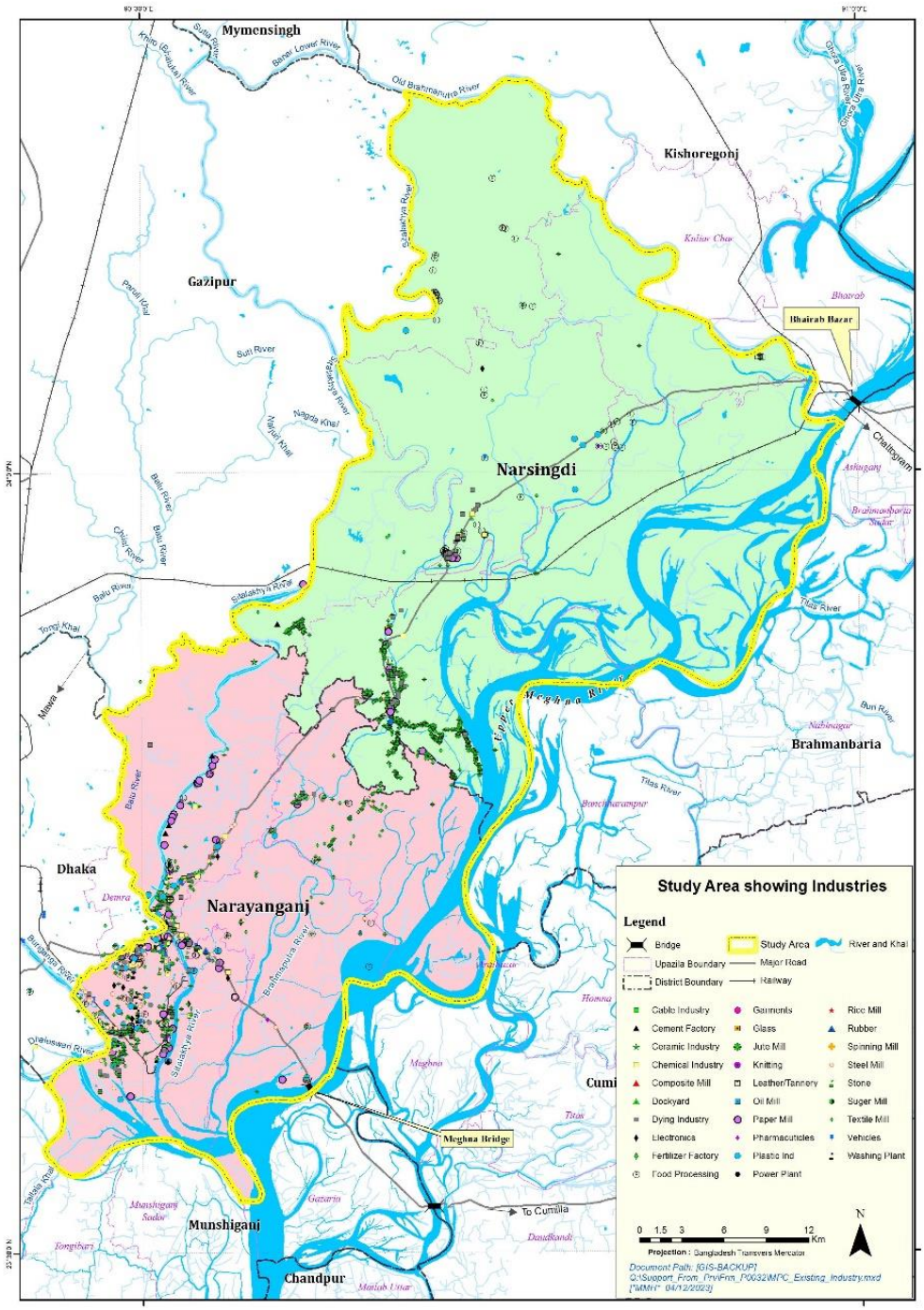
- A properly designed biological treatment plant, which typically includes screening, equalization, pH control, aeration, and settling, can efficiently satisfy BOD, pH, TSS, oil and grease requirements. However, the compounds in industrial effluent may be toxic to the microorganisms used for treatment, as such pretreatment may be necessary. Most dyes are complex chemicals and are difficult for microbes to degrade so there is usually very little colour removal.
- Another option is a physico-chemical treatment plant, which typically includes screening, equalization, pH control, chemical storage tanks, mixing unit, flocculation unit, settling unit and sludge dewatering. This type of treatment removes much of the colour depending on the processes used. It can be difficult to reduce BOD and COD to meet effluent standards and it is not possible to remove TDS by this process.
- Most often, physico-chemical treatment process is combined with biological treatment process. The typical components of such a plant are screening, equalization, pH control, chemical storage, mixing, flocculation, primary settling, aeration, and secondary settling. The physico-chemical treatment always comes before the biological treatment units. Using a combination of treatments will generally reduce pollutant levels below the discharge standards.

Another form of biological treatment is the reed bed, which can be used with a settling tank, or in combination with other treatment processes. It presents a natural method of treating effluent which is often lower in capital, operation and maintenance costs. Reed beds can contribute to a reduction in colour, a decrease in COD, an increase in dissolved oxygen and a reduction in heavy metals, but function best with some form of pretreatment.

2. METHODOLOGY

2.1 Study Area

The study area is the industrial area in Narayanganj and Narsingdi districts as shown in Figure 1. The Upper Meghna River is being used as a sink for rainfall-runoff of the surrounding catchments as well as the disposal of all types of wastewaters within this buffer zone. The industries established in this area are of green, yellow, orange, and red categories. Most of the red and orange category industries are water polluting industries such as: Textile, Cement, Chemical, Composite Mill, Dyeing, Washing, Printing, Food, Garments, Glass, Knitting, Machinery, Metal, Paper Mill, Pharmaceuticals, Plastic, Spinning Mill, Steel Mill, Sugar Mill, etc. There are about 1,200 nos. water polluting industries in this vicinity.



Source: Study team

Figure 1: Study area

2.2 Data Collection and Processing

Industrial database has been collected from Department of Environment's (DoE) central office and district level offices under Master Plan on Meghna River Project (LGD, 2023) which include amount of effluent generation, ETP capacity, type of process, inlet and effluent quality data, etc. The water quality data before treatment (B/T) and after treatment (A/T) has been collected for 2021-2022 from 312 nos. industries among which about 50% is dyeing industries. In a regular basis, DoE collected water samples from the inlet (B/T) and outlet (A/T) of ETP and tested in central laboratory of DoE situated in Dhaka following the standard methods (APHA, 1998). The water quality data includes parameters

of pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total dissolved solid (TDS)

The dyeing industries follow treatment processes of biological, chemical, bio-chemical or physio-chemical with biological. Except dyeing industries, other industries do not follow bio-chemical treatment process. So, the collected data has been analysis by dividing the water polluting industries into two categories: (i) Dyeing industries, and (ii) Other type of industries such as textile, papermill, pharmaceuticals, chemical, oil refinery, food, etc.

The Government of Bangladesh prepared and implemented Environment Conservation Act (ECA) in 1995 and subsequently prepared and implemented Environment Conservation Rules (ECR) in 1997. The ECR has been upgraded in 2023 which has been published on March 5th, 2023. Under the ECR (2023) there is schedule 5 in connection with Environmental Quality Standards (EQS) for industrial effluent. In Schedule 5, Environmental Quality Standard (EQS) has been set for pH, BOD, COD and TDS as given in Table 1. No EQS is set for DO concentration.

Table 1: Environmental Quality Standards (EQS) for industrial effluent

Parameter	Unit	EQS
pH	-	6-9
BOD	mg/l	30
COD	mg/l	200
TDS	mg/l	2100

The performance of ETPs have been analysis based on effluent (A/T) water quality for pH, BOD, COD and TDS comparing with ECR (2023). Percentage (%) of ETP functionality has been estimated based on following formula:

$$\%\ of\ ETP\ functionality = \frac{No.of\ ETP\ that\ can\ maintain\ EQS}{Total\ No.\ of\ ETP} \times 100 \quad (1)$$

3. RESULTS AND DISCUSSION

The outlet water quality for pH, BOD, COD and TDS is compared with ECR (2023) and are presented in Figure 4 and Figure 5. Moreover, percentages of performance compliance with EQS of DoE for dyeing and other industries are presented in Figure 2 and Figure 3.

The wastewater at the outlets of dyeing and other industries are heavily polluted with high organic loading and dissolved solids which are treated in the ETPs before discharging into the environment.

It has been observed from the ETP effluent water quality data in dyeing industries that about in 90% to 100% cases pH level can comply with EQS of DoE through various treatment processes. For BOD and COD, the compliance is about 61% to 80% and 93% to 100% respectively compared with the EQS of DoE. Performance in removing TDS is about 82% to 95% compared with EQS of DoE. In some cases, the effluent TDS increase than the inlet of ETPs (as shown in Figure 4 above the dotted line and the line of perfection). Moreover, BOD removal efficiency in all ETP treatment process is lower compared to other parameters. Among the different ETP treatment processes, Physico-Chemical & Biological treatment process is relatively best suited in removing BOD, COD and TDS.

The ETP effluent water quality data for industries other than dyeing industries show that about 95% to 100% pH level can comply with EQS of DoE. For BOD, the compliance is about 66% to 69%, for COD is about 80% to 88%, and for TDS is about 75% to 93% as compared with EQS of DoE. Similar to dyeing industries, in other industries effluent TDS increase than the inlet of ETPs (as shown in Figure 5 above the dotted line and the line of perfection). BOD removal efficiency in all ETP treatment process of other types of industries is also lower compared to other parameters.

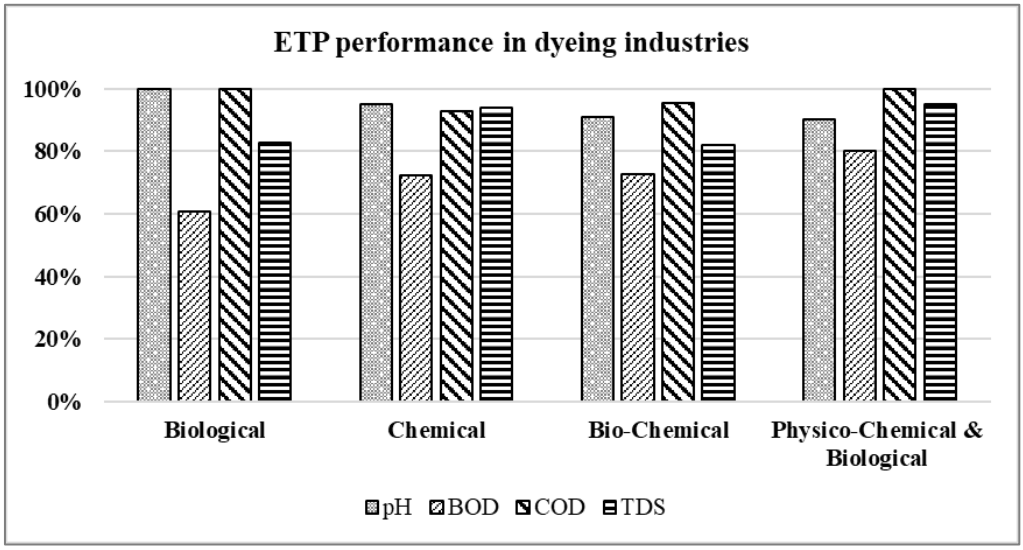


Figure 2: ETP Performance compliance with EQS in dyeing industries

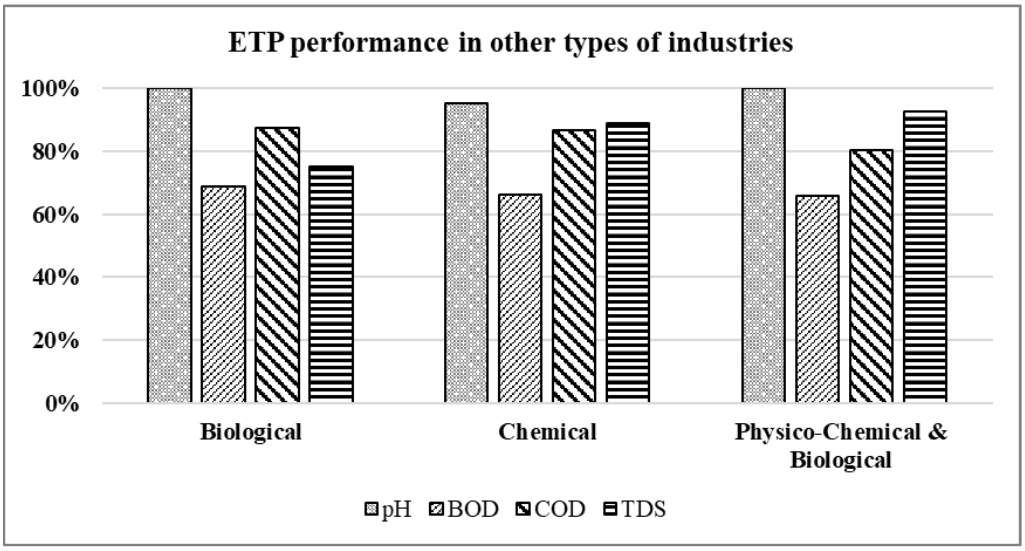
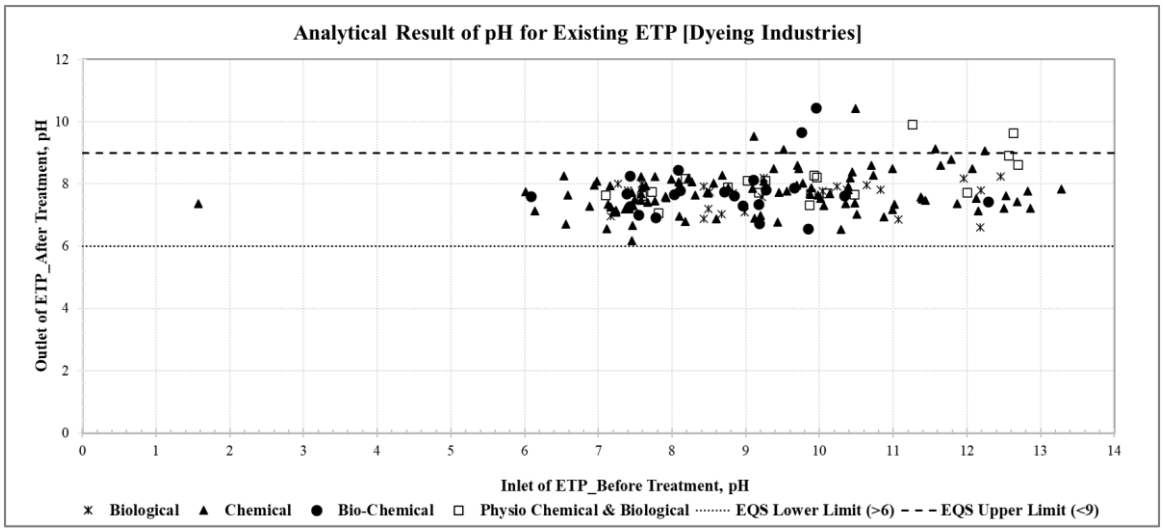
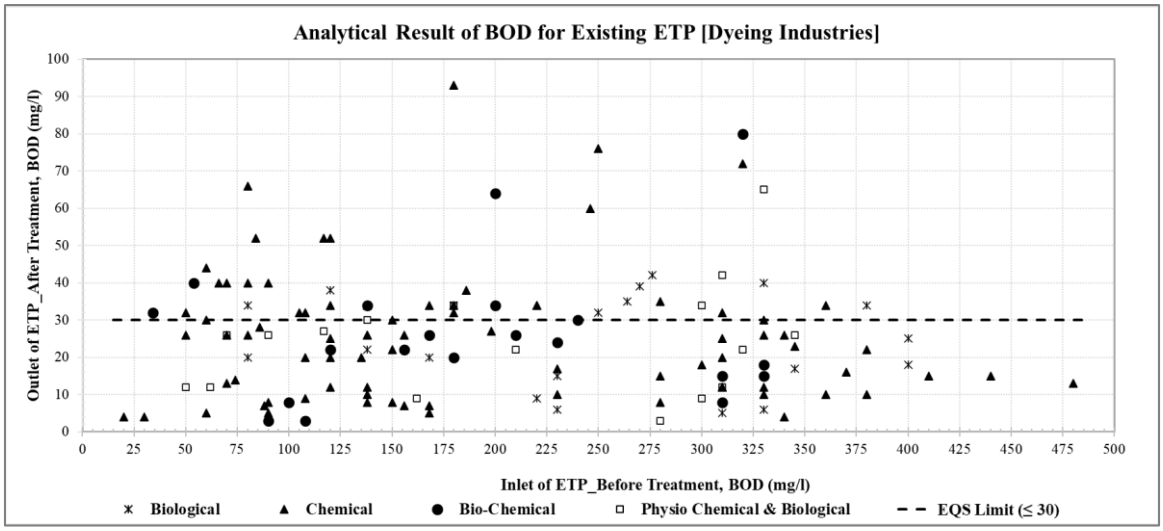
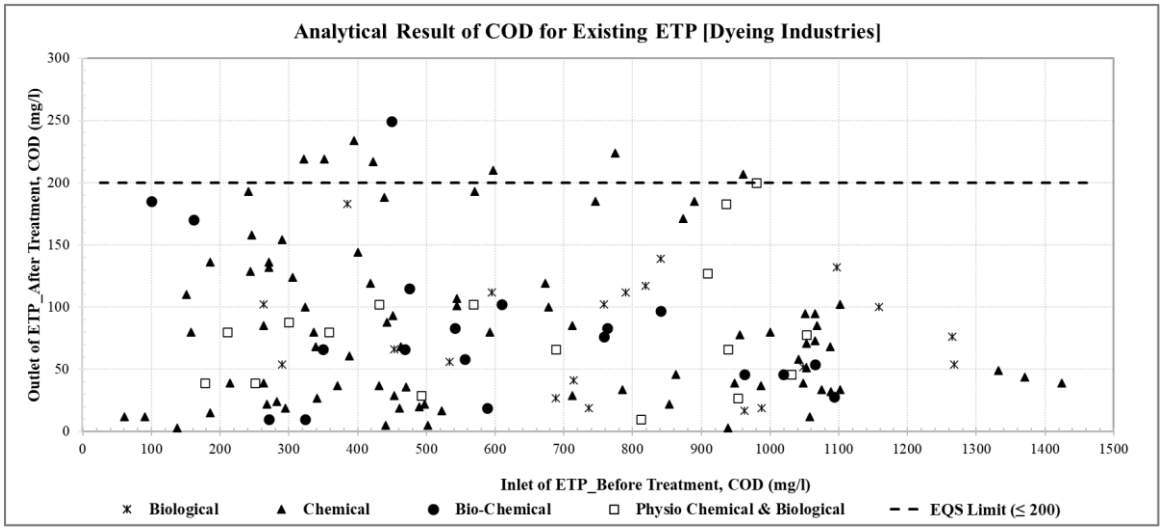


Figure 3: ETP Performance compliance with EQS in other industries







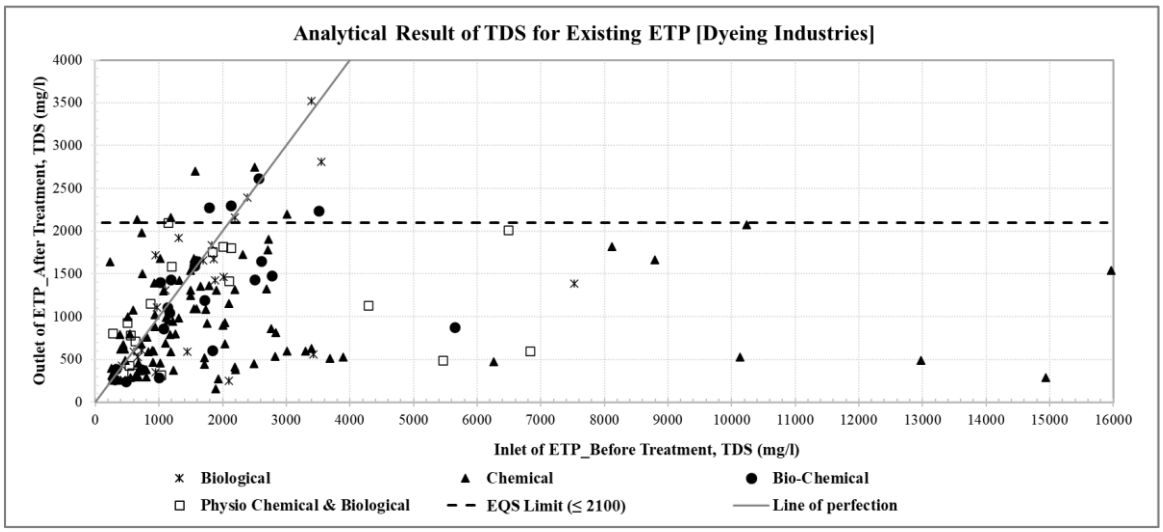
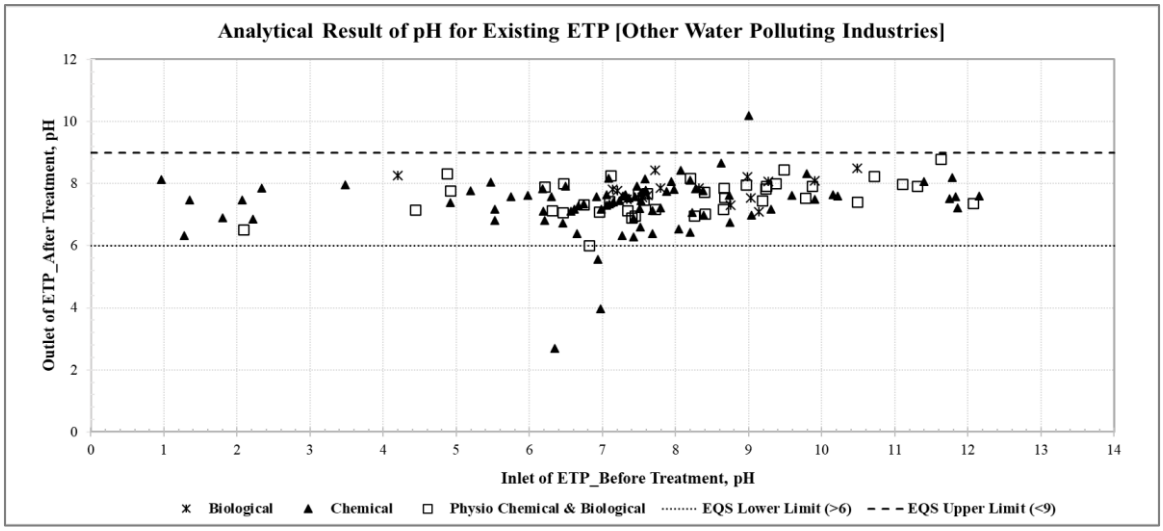
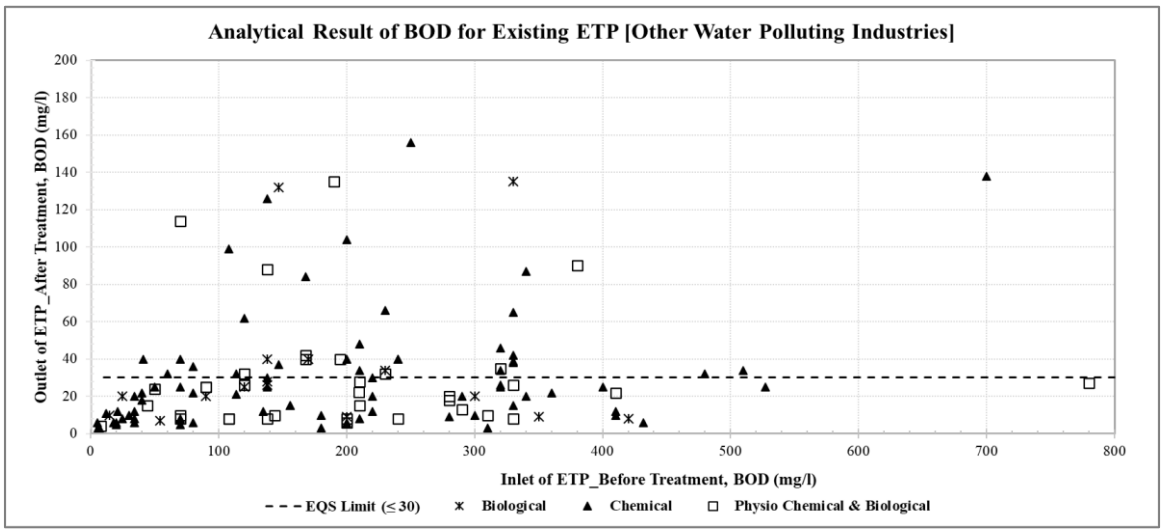
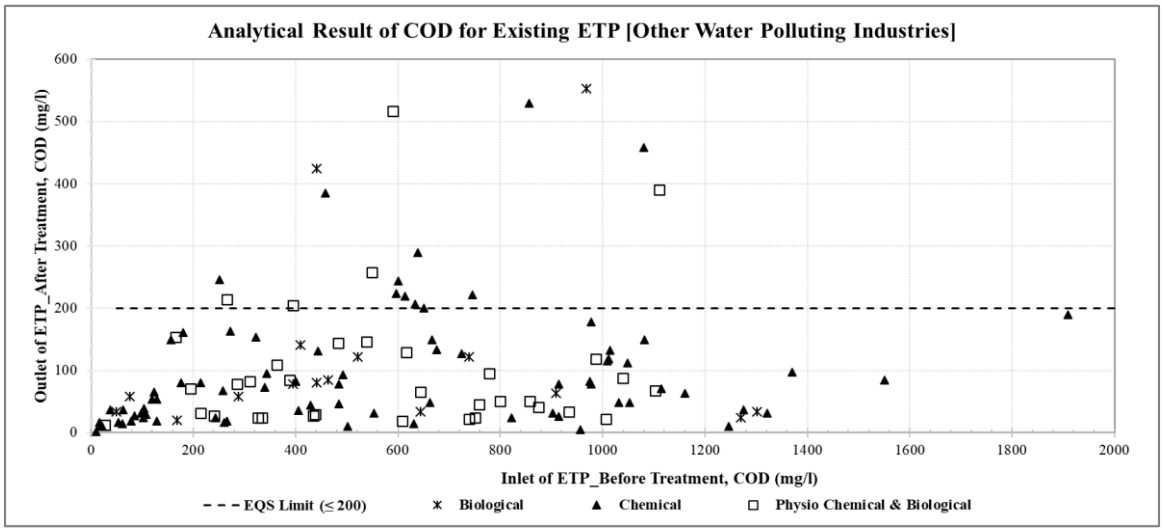


Figure 4: Performance analysis of ETP for pH, BOD, COD and TDS in dyeing industries


Analytical Result of pH for Existing ETP [Other Water Polluting Industries]
Outlet of ETP_After Treatment, pH
Inlet of ETP_Before Treatment, pH
Biological
Chemical
Physio Chemical & Biological
EQS Lower Limit (>6)
EQS Upper Limit (<9)


Analytical Result of BOD for Existing ETP [Other Water Polluting Industries]
Outlet of ETP_After Treatment, BOD (mg/l)
Inlet of ETP_Before Treatment, BOD (mg/l)
EQS Limit (≤ 30)
Biological
Chemical
Physio Chemical & Biological


Analytical Result of COD for Existing ETP [Other Water Polluting Industries]
Outlet of ETP_After Treatment, COD (mg/l)
Inlet of ETP_Before Treatment, COD (mg/l)
EQS Limit (≤ 200)
Biological
Chemical
Physio Chemical & Biological

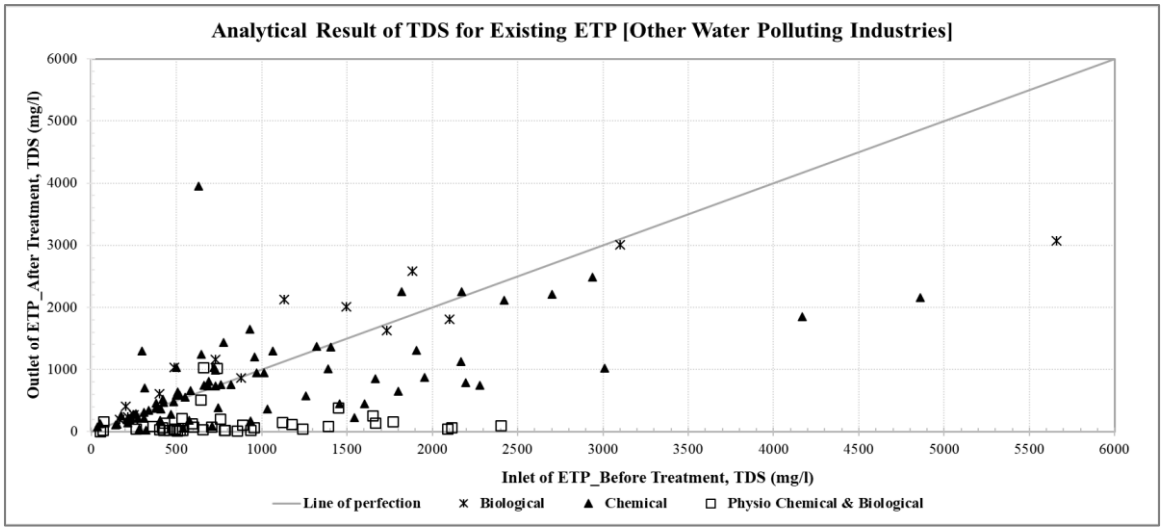


Figure 5: Performance analysis of ETP for pH, BOD, COD and TDS in other types of industries

Moreover, the ETPs perform better in lowering concentration of BOD and COD in all types of industries as shown in Figure 6 and Figure 7. But no treatment process is suitable in reducing concentration of TDS. Efficiency in removing pollutants is comparatively more in dyeing industries than other types of industries, especially in removing TDS. Even in biological process TDS concentration level increase in other types of industries. Therefore, no treatment process is suitable in lowering TDS value which can comply with EQS of DoE. However, for water pollution control, more advanced treatment process is required to improve performance of ETPs.

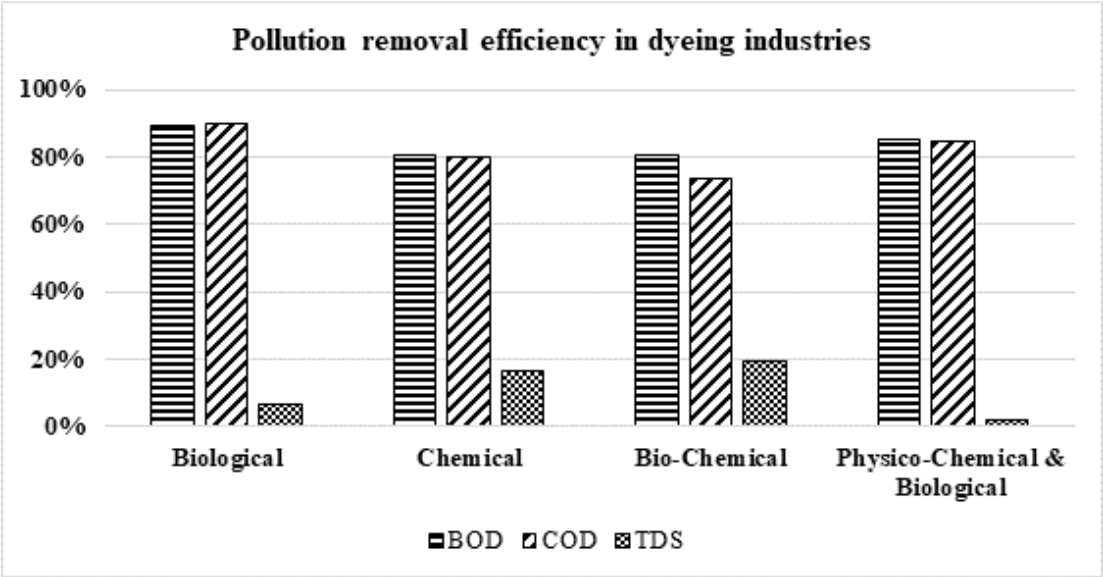


Figure 6: Pollution removal efficiency in dyeing industries

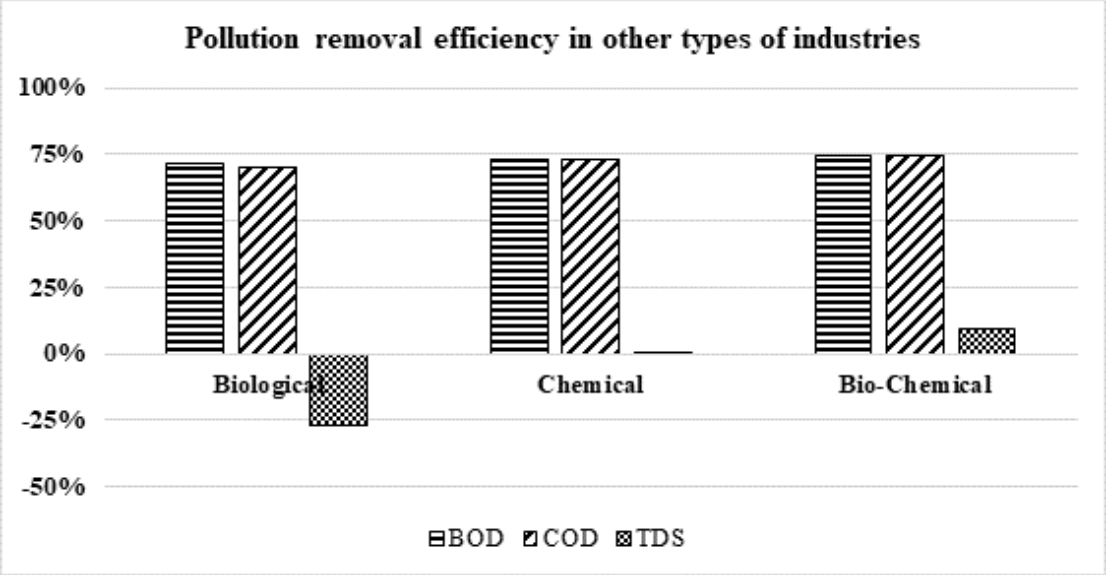


Figure 7: Pollution removal efficiency in other types of industries

4. CONCLUSIONS

The performance evaluation of ETPs in dyeing industries is more efficient than other types of industries. However, ETPs functionality is worst in BOD removal than other parameters. Moreover, the effluent TDS increase than the inlet of ETPs which need to be controlled. It is recommended to upgrade the efficiency of the existing ETPs or replace them by advanced ETP and more quality control during operation and maintenance for environmental compliance and proper water pollution control. If there is scarcity of land for new ETP establishment or upgradation, two or more similar types of industries can establish common effluent treatment plants (CETP) of advanced technology. Moreover, capacity building initiatives need to be taken for developing skilled manpower to operate such ETPs.

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