# INTEGRATION OF TECHNOLOGIES TO IMPROVE THE PHARMACEUTICALS WASTE MANAGEMENT IN BANGLADESH

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***Abstract:*** *An investigation was carried out to minimize the pollution load of pharmaceuticals industries by using integrated waste management technologies. Effluents were physically, chemically and biologically treated using three-stages advanced effluent treatment system. The dust particles were discharged to the atmosphere after filtration and the solid wastes were burnt in a pyrolytic incinerator at about 1100$^{o}$C temperature. The physico-chemical characteristics of treated effluent were measured using Ultra Violet-Visible spectrophotometer and the emitted dust particles were analyzed using High Performance Liquid Chromatography (HPLC) to determine the discharge amount. The biological oxygen demand, chemical oxygen demand, total dissolved solid, chloride and sulphide contents of the treated effluent were found within allowable limit. The dust particles were also emitted to the environment below 0.5 mg/L. The solid wastes were reduced to 25% by volume after combustion. It was found that integrated waste management system of pharmaceutical industries can minimize the pollution load to ensure a safe ecological environment.*

***Keywords:*** *Waste Management Technology, Effluent, Solid Waste, Pharmaceuticals Waste.*

## 1. Introduction

Industrial Pollution in Bangladesh is mainly generated from different kinds of manufacturing industries product intermediate and final products. Recently, in this country the pharmaceutical industries are making headways in responsible for the disposal of hazardous waste. Hazardous wastes can take the form of liquids, solids, contaminated gas or sludge. They can be the by-products of the manufacturing processes or may consist of discarded commercial products, such as cleaning fluids, pesticides. The solid part of this waste is disposed to the open land and dumped in water [1]. The liquid and gaseous parts are released in water and air respectively with or without any treatment [2].

The impact of pharmaceutical wastes in the surrounding environment is raising concerns about the potential adverse environmental consequences [3]. Some of the pharmaceutical wastes are having detrimental effects on aquatic species [4] and possibly on human health and surrounding lands [5, 6]. The consistent increase in the use of potent pharmaceuticals, driven by both drug development and our aging population, is creating a corresponding increase in the amount of pharmaceutical waste being generated. Pharmaceutical wastes are potentially generated through a wide variety of activities in a health care facilities which include tablet preparation, encapsulation, liquid preparation, intravenous preparation, general compounding, spills/breakage, partially used vials, syringes, and IVs, discontinued, unused preparations, unused unit dose repacks, unused packaging materials and outdated pharmaceutical products. The plants for synthetic drugs utilize a large number of both organic and inorganic chemical, which usually produce a variety of drugs in different sections of the plant [7]. In general, most of the wastes are toxic to biological and aquatic life and are usually characterized by high BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), TDS (Total Dissolved Solid) and suspended solid content [8]. Wastes from these plants are either highly alkaline or highly acidic. In Bangladesh, pharmaceutical industries are responsible for 15.9% water pollution and 12.6% toxic chemical emission to the environment among the other polluting industries in the country [9].

Wastes containing toxic elements like cyanide and heavy metals, if discharged without any treatment are harmful to the aquatic life in the stream. These toxic elements interfere with the biological sewage treatment units very badly,

such as acidic wastes corrode the physical structure of the sewerage system. Due to high BOD in raw waste, it rapidly depletes the Dissolve Oxygen (DO) of the stream. The dust particles generated from different processing section can pollute the surrounding atmosphere of the pharmaceutical industries. The solid wastes are destroying the fertility of surrounding land. Several effective technologies are available to deal with and minimize the release of waste effluent [10, 11], dust particulates and solid wastes to the surrounding environment [12]. The aim of the present study is to summarize the integrated technological management of different types of pharmaceutical wastes and discharge to environment within the allowable limit.

## 2. Experimental

### 2.1 Technologies for Effluent Treatment

Generally three types of waste stream are generated from pharmaceutical industries: process waste water, utility waste water, and domestic waste water. The combine waste streams from different areas of the pharmaceutical industries were subjected to consecutive three stages of treatment- (a) physical treatment, (b) chemical treatment, and (c) biological treatment. Biological treatments again can be subdivided into two types: (i) anaerobic and (ii) aerobic biological treatment.

### 2.1.1 Physical Treatment

Physical treatments were used primarily to remove the unwanted solid substances from the waste stream. Raw waste stream were subjected to pass through the bar racks for screening followed by grit chamber and sedimentation tank. The waste sludge, collected from the sedimentation tank, was then sent to the solid waste treatment plant for combustion and the effluent was passed to the chemical treatment plant.

### 2.1.2 Chemical Treatment

The simplified flow sheet for chemical treatment of pharmaceuticals effluent is shown in the Fig. 1. The effluents, collected from the physical treatment plant, were neutralized with lime in the neutralization tank and then alum was added to the flash mixing tank and the effluents were taken to the flocculation tank. After flocculation the settleable solids were removed from the sedimentation tank and sent to the solid waste treatment plant and the decant solution were further treated in the equalization tank.

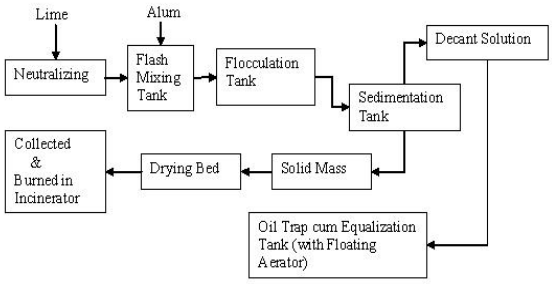


Fig.1: Typical simplified flow sheet for chemical treatment of waste water.

### 2.1.3 Biological Treatment

From the equalization tank, the effluents were subjected to two steps biological treatment. In the first step, anaerobic digestion was carried out by acidogenesis and volatile organic acids were formed [13]. Then they were converted to acetic acid and methane through acetogenesis and methanogenesis respectively. A simplified flow sheet of anaerobic biological treatment of pharmaceuticals waste is shown in the Fig. 2.

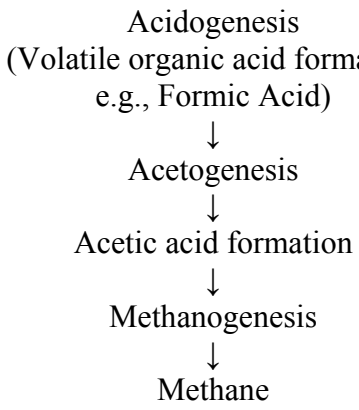


Fig.2: Simplified flow sheet of anaerobic treatment of pharmaceuticals waste effluent.

After anaerobic treatment the effluents were again treated by two stages aerobic digestion after settling in the hopper bottom settling tank, which is depicted in the Figure 3.

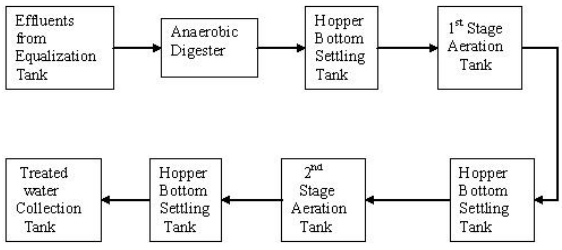


Fig. 3: Flow sheet for the biological treatment of waste water.

### 2.1.4 Liquid Sample Collection and Preparation

The treated water were collected from the collection tank for the determination of pH, chemical oxygen demand (COD), biological oxygen demand (BOD), total dissolved solid (TDS), dissolve oxygen (DO), chloride, sulphide content and electrical conductivity. pH and electrical conductivity were measured electrochemically using a calibrated glass electrode pH/Conductivity meter (Sartorius, Model - PP15, Germany). Chemical oxygen demand (COD), biological oxygen demand (BOD), total dissolved solid (TDS), dissolve oxygen (DO), chloride and sulphide content were measured in the laboratory directly using spectrophotometer (HACH, Model - DR500, USA). Demineralized water was used as a blank in this study.

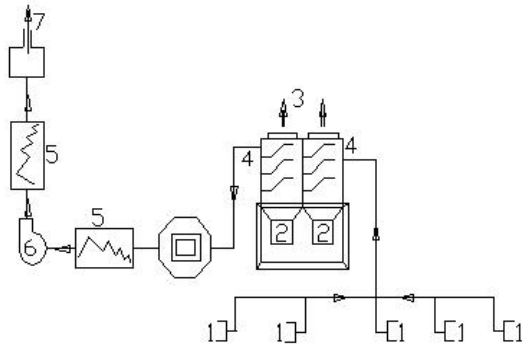


Fig. 4: Typical dust collection system:
1. Dust collecting spaces 2. Dust store boxes 3. Top explosion relief 4. Filter units
5. Attenuator 6. Blower 7. Exit air

### 2.2 Technology for Dust Collection System

The dust collector was installed at the heating, ventilation and air conditioning (HVAC) system. The central dust extraction system was connected with the production units.

The extracted dust particles were then filtered (0.2 µ) and thrown to atmosphere. The filters were cleaned by compressed air jet which was an automatic time controlled operation. In a periodic manner, dusts were collected from the collection bin and disposed off by incinerator. The dust collection system connected with HVAC system is shown in the Fig. 4.

### 2.2.1 Dust Sample Collection and Dilution

Dust sampling areas are the outlet of the production areas (exhaust). Particulate in the air were collected by swabbing the gelatinized filter which was used for Air Borne Particle counter using diluent of the specific product [14]. The collected air borne particulate were taken in 100 $cm^3$ calibrated volumetric flask with proper label and were diluted to volume according to the test procedure for that specific active material in conjunction with appropriately dilute solution of Working Standard (0.5 mg/L) of that specific active materials. The sample and standard were analyzed with a High Performance Liquid Chromatography (HPLC) for the determination of discharge limit of the dust particles (Cefixime active) to the surrounding atmosphere.

Hypersil 0.125 m long and 4 mm internal diameter column, packed with octadecylsilyl silica gel (5 µm) was used for chromatographic analysis. Mobile phase was prepared by the mixture of 250 volumes of acetonitrile and 750 volumes of a tetrabutylammonium hydroxide solution. Tetrabutylammonium hydroxide solution was prepared by dissolving 8.2 g of tetrabutylammonium hydroxide with 800 $cm^3$ demineralized water and pH was adjusted to 6.5 with dilute phosphoric acid and finally was diluted to 1000 $cm^3$ with demineralized water.

High Performance Liquid Chromatography (HPLC- Shimadzu Prominence, Japan) with 1.0 $cm^3$/min flow rate, 10 µl loop injector, 40°C column oven temperature and detection wavelength 254 nm (PDA detector) was used for this analysis.

### 2.3 Technology for Solid Waste Management

The solid wastes are mainly dry sludge of effluent treatment plant (ETP), objects from kitchen food stuff, rejected foils and other pharmaceuticals unused materials etc. These solid wastes were taken in a pyrolytic based incinerator.

The whole incineration system was maintained under negative pressure by induced draft (ID) fan. This was done in order to prevent backfire due to positive pressure inside the system, thereby safe guarding the operator from possible hazards. Primary combustion chamber (PCC) was maintained at 750°C, secondary combustion chamber (SCC) was maintained at temperature of 1050°C. At 700°C in primary combustion chamber solid waste at the rate of 100 kg/hr was fed manually through feed door mounted on PCC maintained under pyrolytic condition. The gasified waste formed due to starved air combustion of solid waste in primary combustion chamber was then passed through

secondary combustion chamber maintained at elevated temperature 1100°C under access air condition wherein complete combustion of gasified waste was ensured. The hot flue gases from SCC were diluted by online direct ambient air and were then passed through wet cyclonic scrubber where the hot flue gasses were scrubbed with pre calculated quantity of cold water was circulated by water recirculation pump.

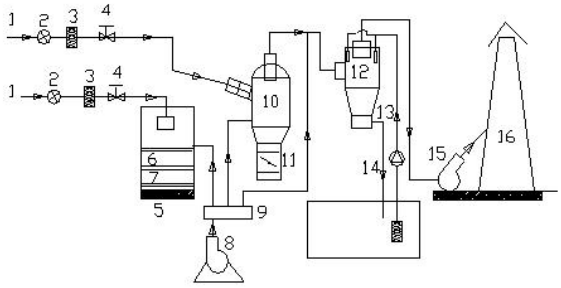


Fig. 5: Typical incinerator for solid waste management: 1. Natural gas inlet 2. Ball valve 3. Filter 4. Safety valve 5. Primary combustion chamber (PCC) 6. Feed door 7. Ash tray 8. Force draft (FD) fan 9. HD 10. Secondary combustion chamber 11. Draft Feed Valve 12. Wet cyclone scrubber 13. Water spry line 14. Used water line 15. Induced draft (ID) fan 16. Chimney.

During the process the particulate matters and other hazardous fumes present in the flue gas were removed and the temperature of flue gas reduced to 200°C. During the process the temperature of cold water rose marginally. The flue gases at 200°C were then vented out to stock through ID fan. The force draft (FD) fan supplied combustion air to PCC, SCC and also cooling air to the inlet duct of SCC to cyclone. pH value of recirculation tank was maintained 7 to 8 by dosing NaOH or acid. The flue gases were then scrubbed and the remaining waste sent to landfill.

### 3. Results and Discussion

The physico-chemical characteristics of waste effluent generated from the pharmaceuticals industries after physical, chemical and two stages biological treatments are shown the Table1.

It is found from the Table 1 that after integrated treatment of the combined effluent of a pharmaceuticals industry reduces the pollution load within the allowable range of discharge [15].

Table 1: Physico-chemical characteristics of treated effluent generated from the Pharmaceuticals Industries.
Data are taken on weekly basis

| Parameters | Units | Measured Value | Allowable Range |
|---|---|---|---|
| Color | - | ok | Light brownish |
| pH | - | 7.5~8.2 | 6-9 |
| COD | mg/liter | 245~378 | < 400 |
| $BOD_5$ | mg/liter | 72~81 | < 100 |
| TDS | mg/liter | 1320~1506 | < 2100 |
| DO | - | 5.3~7.2 | 4.5-8 |
| Chloride | mg/liter | 487~590 | < 600 |
| Sulphide | mg/liter | 0.8~1.6 | < 2 |
| Conductivity | Micro siemen/ $cm^2$ | 1090~1120 | < 1200 |

The amount of dust (Cefixime) found in the air sample are identified by comparing the retention time of the peak from the chromatogram of cefixime standard (0.5 mg/L) and the chromatogram of the sample. Figure 6 shows the chromatogram of cefixime standard (0.5 mg/L) and it is seen that the peak of cefixime standard (0.5 mg/L) is found at 3.222 minutes.

Fig.6 Chromatogram of cefixime standard (0.5 mg/L)

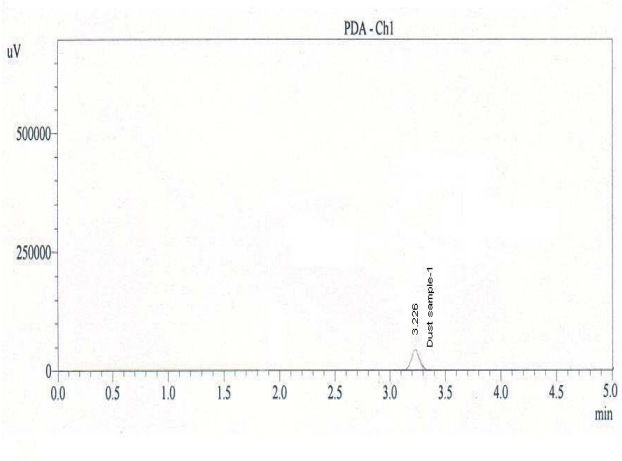


Fig. 7: Chromatogram of sample (exhaust – air sampling)

From the Figure 7 we find the peak of cefixime active in the sample (exhaust–air sampling) at 3.226 minute. The peak area of the sample and standard are taken in consideration for this comparative study.

**Table 2.** Peak area of cefixime standard (0.5 mg/L) and sample.

| Run | Retention Time (Minute) | Peak Area | | AVA [a] | Peak Height (AU) [b] | Concentration (mg/L) | % RSD [c] |
|---|---|---|---|---|---|---|---|
| | | Maximum | Minimum | | | | |
| Standard (0.5 mg/L) | 3.222 | 12650 | 12611 | 12635 | 548566 | 0.5 | 0.679 |
| Sample (exhaust) | 3.226 | 1097 | 994 | 1063 | 44521 | 0.04 | 1.116 |

[b] Average Peak Area, [b] Absorbance Unit, [c] Relative Standard Deviation

Table 2 indicates the acceptable low RSD (0.679%) for the peak areas of cefixime standard (0.5 mg/L). The average peak area of 0.5 mg/L cefixime standard is found 12635 and that for the sample is found 1063. From the cephalosporin area it is found that the outlet air is discharging about 0.04 mg/L cefixime, which is less than 0.5 mg/L.

In the incinerator the calorific value of solid wastage is found about 4000 Kcal/kg. Organic compounds present in the waste are converted into non toxic gases which are let out into an atmosphere after scrubbing. Furthermore, since combustion reduces the toxicity and volume of waste, residues from combustion are more amenable to land disposal than the original waste streams. This is especially important in our country where landfill sites are becoming increasingly scarce and expensive.

## 4. Conclusion

The qualities of effluent, dust particles and solid waste that were discharged to the environment after integrated pharmaceuticals waste treatment were found below the set limits by the government of Bangladesh [15]. Pharmaceutical companies and researchers are beginning to believe that the solution lies not just in the safe disposal of pharmaceutical waste, but also in the production of less waste [16]. So, considering the situation in Bangladesh, it is strongly recommended that the combined wastes generated form the pharmaceutical industries should be properly treated through the integrated waste management system for the minimization of the pollution load under the industrial policy of the government.

## Acknowledgement

This work is supported by Square Pharmaceuticals Limited located in Kaliakoir, Gazipur, Bangladesh, the first MHRA approved Pharmaceuticals Company in Bangladesh.

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