

Research Article

Pharmaceutical Effluent Treatment Using Multi-effect Evaporator Process

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The disposal practices of pharmaceutical-generated pollutants have become a serious threat to mankind's health, safety, and environmental concerns. Pharmaceutically polluted effluents have been demonstrated as endocrine disruptors which mimic growth hormones when consumed at nG/L to mG/L concentrations. The production stages utilize both organic and inorganic compounds, which contribute to chemical oxygen demand (COD) and total dissolved solids (TDS) heavily. Conventional technologies have failed to accomplish zero liquid minimization. To achieve zero minimization, it is necessary to develop modernization techniques in effluent treatment streams. A novel technique to recover solids and organic matter removals as well as zero-liquid discharge (ZLD) flash mixer, stripping, and multi-effect evaporator (MEE) processes is employed. Flash mixing is a pre-treatment stage, and stripping enables solvent reclamation. The multi-effect evaporators involve heat transfer equipment mainly used for volume reduction and cutting down on waste handling costs. The multi-effect evaporator not only is able to eliminate pharmaceutical xenobiotics but also requires pre-treatments such as flash mixture and stripping column sections. Thus, this research emphasizes efficiently removing high total dissolved solids (HTDS) and high chemical oxygen demand (HCOD) from pharmaceutical effluent. The removal efficiency was found to be 85% for TDS and TSS, 93% for BOD, and 81% for COD, which is more than the conventional mode of treatment.

1. Introduction

In an arrangement to frame a salubrious and sound climate, water quality ought to be checked to such an extent that it exists in each of the separate principles. Among the various natural groups that India is confronting for 100 years, freshwater shortages are extremely high [1]. Water is a basic product for the life of every single living organic entity and an inestimable source on the Earth, yet this esteemed asset is progressively being compromised as human populations develop and injunctively approve more water for gardening

purposes [2]. Wastewater is a fluid waste, released by business properties, house gardening, horticulture, and industry, which frequently contains a few foreign substances that result from the blending of wastewater from various sources [3]. In the event that appropriate plans for assortment, treatment, and removal of all the waste delivered by the city or town are not made, they will continue gathering and creating conditions that compromise the security of the designs, with the end goal that structures and streets will be harmed because of the collection of wastewater in the establishments. Furthermore, sickness-causing microbes will

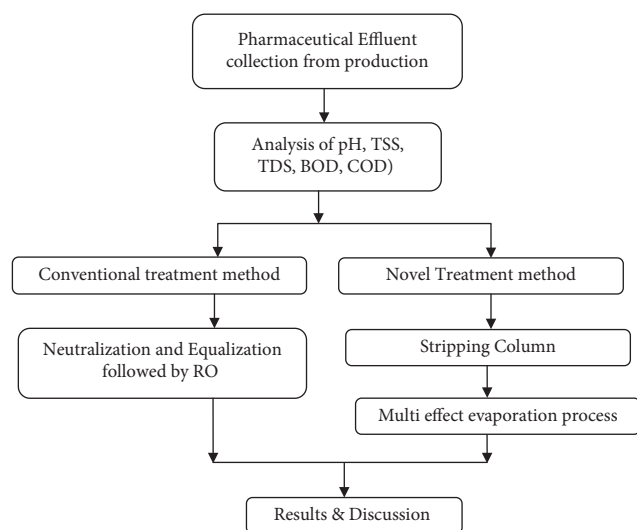


FIGURE 1: Flow diagram of methodology.

rise in the stale water, and the soundness of the public will be in danger. Wastewater is any water that has been antagonistically impacted in quality by anthropogenic impact. It contains fluid waste released by house gardening, business properties, industry, and additionally, natural culture and can envelop a wide scope of expected pollutants and focus [4].

Most earthly usage alludes to municipal waste that contains an expansive range of toxins, coming about because of the blending of wastewater from various sources. According to estimates, anticipated wastewater from urban areas might reach 120,000 MLD by 2051, with rural India generating at least 50,000 MLD due to water supply designs for communal supplies in rural areas [5]. Most wastewater management plans, on the contrary, ignore the rising rate of wastewater generation. According to the Central Pollution Control Board (CPCB), India has 269 sewage treatment facilities (STPs); however, only 231 of them are operational. As a result, existing treatment capacity only covers 21% of current sewage generation. Untreated sewage is the primary source of pollution in rivers and lakes. The vast majority of STPs built under central funding schemes such as the National River Action Plan's Ganga Action Plan and Yamuna Action Plan are not fully operational [6].

Heavy metals have been removed from wastewater using traditional procedures such as coagulation, electro-floataion, electrocoagulation, and electrodeposition [7]. However, they have a number of drawbacks, such as inadequate metal removal, sludge generation, and high energy requirements. Due to these drawbacks, a cost-effective, efficient, and environmentally friendly alternative approach known as "biosorption" can be used to remove heavy metals from wastewater. Microorganisms, plant-derived materials, agriculture or industrial waste, and biopolymers are all examples of biosorbents [8].

"Ordinary wastewater treatment processes do not wipe out drugs and chemicals, bringing about the arrival of low levels of these mixtures into the climate," said Pedersen. The

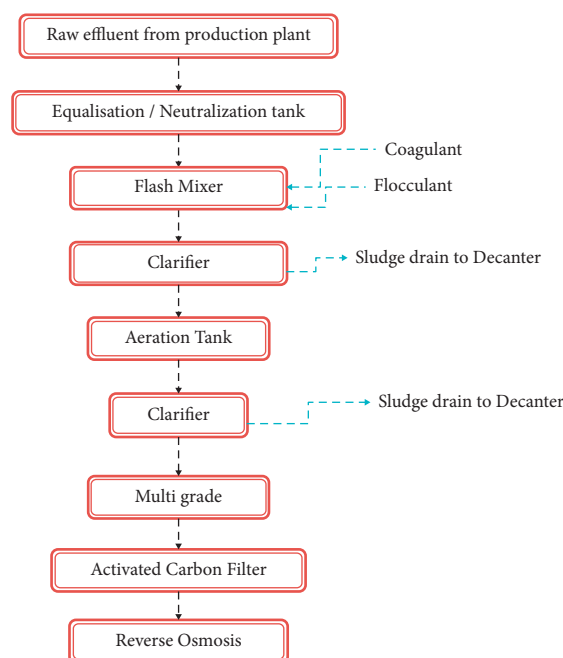


FIGURE 2: Conventional treatment method.

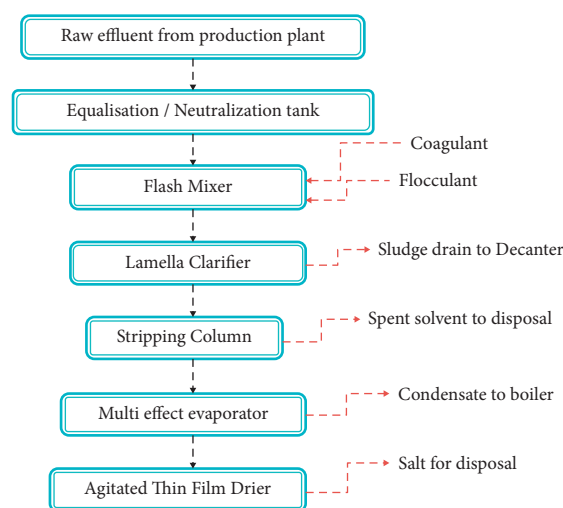


FIGURE 3: Novel treatment process.

further developed processes do a very great job at eliminating compounds. Drug wastewater contains around 99.99% of water and 0.01% of different materials as disintegrated solids. For the most part, drug wastewater contains drug drugs (API and excipients) from creation, synthetic compounds and solvents from quality control, and oil and oil from utility and upkeep. In [9, 10], research was conducted on the phosphate minimizers through the screening process and clients to eliminate the phosphate from Pharma squander water utilizing a clump scale process. The three most effective phosphate minimizers were secluded and screened from the eutrophic lake water and wood soil tests. Among the singular strains, *Pseudomonas* sp was seen to be 68% evacuated at impartial pH. Contrasting with individual types of every microscopic organism, the blend of

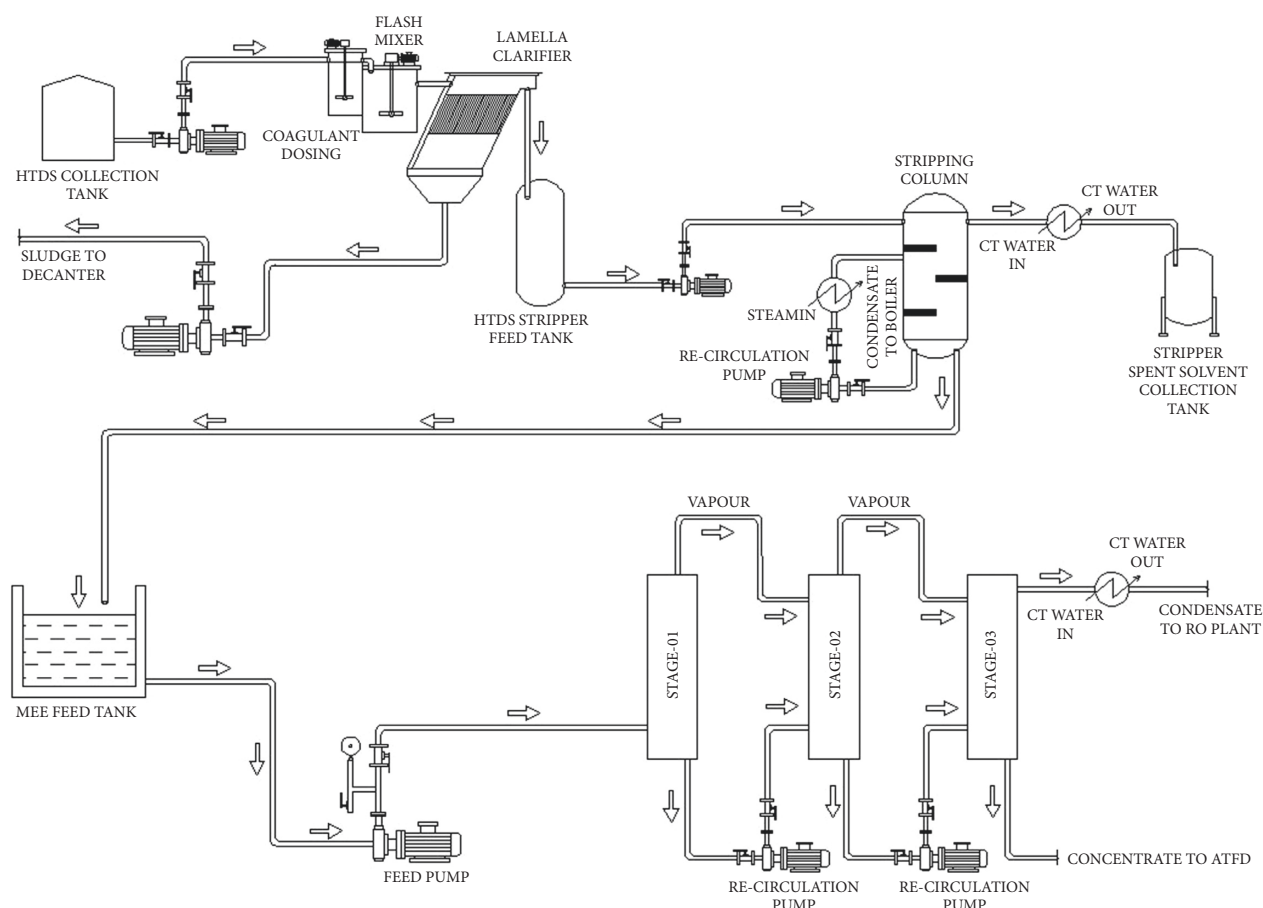


FIGURE 4: Block diagram of novel treatment process.

Pseudomonas, *Bacillus*, and *Enterobacter* was seen to have a limit of 92.5% at a pH of 7 to 5. Along these lines, the microorganisms might use the pollutant's supplements as energy sources or they might be used by co-digestion. Subsequently, this microorganism's segregation may be utilized in the remediation of phosphate-polluted environments.

The phytoremediation strategy for the treatment of various sorts of wastewater has been utilized by a few scientists [11]. These procedures are considered to be financially savvy compared with different techniques. Different pollutants such as complete suspended solids, disintegrated solids, electrical conductivity, hardness, biochemical oxygen interest, synthetic oxygen interest, broken down oxygen, nitrogen, phosphorous, weighty metals, and different impurities have been decreased in various foreign substances which have been introduced into limited quantities utilizing the stripping section technique and conventional treatment strategy. The disposal of medical waste, particularly pharmaceutical waste, leads to water pollution. A number of pharmaceutical industry effluent disposals and their components create pollution in lakes and rivers [12]. The environment and health are directly or indirectly affected by pharmaceutical

effluents, especially in the vicinity of pharma industrial zones [13]. The highly toxic refractory compounds released from pharmaceutical effluent are limited to their biodegradability, posing a potential threat to the natural ecosystem. Antibiotics produced by the pharmaceutical industry have a significant impact on the environment as they can disrupt effluent treatment processes and adversely affect the environment [14]. The hybrid process of peroxide and adsorption can be applied for the treatment of real industrial pharmaceutical wastewater containing complex organic compounds [15]. Numerous techniques have been developed to deal with such severely polluted effluents, including physicochemical [16] and biological strategies [17]. The development of water conservation strategies and cutting-edge wastewater treatment for water recycling is required due to the limited availability of good-grade water supplies. To eliminate colour from industrial effluents, improved treatment technologies must be developed [18]. Combined physico-chemical and biological treatment is an efficient method for the treatment of persistent compounds [19]. Electrocoagulation using iron sacrificial electrodes for the removal of Cd, Cu, and Ni from simulated wastewater reveals 99.97% removal of Ni at all initial concentrations [20].

TABLE 1: Raw effluent characteristics from pharma industry.

S. no.	Parameters	Plant-1 effluent sample	Plant-2 effluent sample	Plant-3 effluent sample	Plant-4 effluent sample	Combined effluent
1.	pH	8	7.5	6.8	6.8	7.5
2.	TSS, mg/l	2000	1670	2100	1500	2800
3.	TDS, mg/l	14895	13750	14800	12500	15300
4.	BOD, mg/l	9720	10200	6720	7500	8500
5.	COD, mg/l	27000	29230	24480	25200	26500
6.	TKN, mg/l	950	785	620	550	800

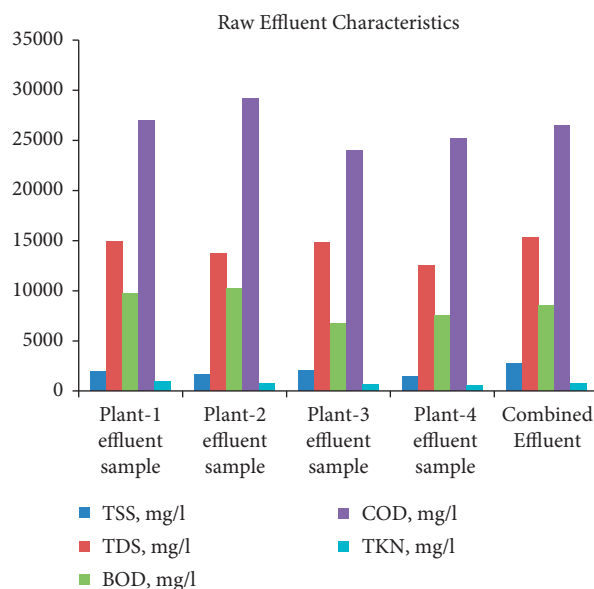


FIGURE 5: Characteristics of raw pharmaceutical effluent.

2. Methodology

The flowchart showing the methodology is presented in Figure 1. The raw effluent was collected from a leading pharmaceutical company as per standard procedure and was brought to the laboratory where the samples were stored in a deep freezer at 4°C before analysing the samples. The methodology employed to analyze pH, TSS, TDS, BOD, and COD is as per the guidelines prescribed by the American Public Health Association [21].

3. Experimental Processes

3.1. Conventional Treatment. The presence of solids, organic materials, and other nutrients is removed from wastewater using a combination of physical, chemical, and biological processes and activities. It refers to a common wastewater treatment process that can lessen the noxious qualities of water-carrying waste, making it less dangerous and unattractive to humans. Figure 2 depicts an overview of conventional treatment stages and how they are linked to each other. The conventional treatment process poses problems during its operation, such as the presence of a high organic load in the clarifier, which produces the bad odour and black colour effluent. In an aeration tank, the COD of the effluent will not reduce more due to less microbial growth.

3.2. Novel Treatment Process. The methodology followed in the novel treatment is presented in Figure 3 and the schematic representation of the block diagram showing the novel treatment is presented in Figure 4. In the novel treatment mode, multiple effect evaporators were used, in which the effluent could not be introduced directly due to its high TDS, resulting in the formation of fouling, odour, and emissions in the evaporators. Hence, the TDS and COD must be reduced before introducing the effluent into the evaporators. The flash mixture tank and stripping column are used in order to reduce spent solvents and TDS in the effluents.

4. Results

4.1. Characteristics of Raw Pharma Effluent. The wastewater of every pharma interaction comprises contamination of different pH values. Likewise, an enormous variety exists in each boundary: TDS, TSS, BOD, COD, chloride, pH, and so forth. The characteristics of effluent analyzed for various pharmaceutical plants and their combined parameters are presented in Table 1 and Figure 5.

4.2. Comparison of Conventional and Multi-Effect Evaporator Method. The characteristics of effluent analyzed for pharmaceutical plants using conventional methods and multi-effect evaporators are presented in Table 2. The

TABLE 2: Comparison of pharma effluent treatment.

S. no.	Parameters	Raw combined effluent	Conventional method		Novel treatment method		
			Values	Removal efficiency	Stage 1 air stripping	Stage 2 multi-effect evaporator	
						Values	Removal efficiency
1.	pH	7.5	7.6	—	7.6	8	—
2.	TSS, mg/l	2800	2089	25.39%	1057	404	85.57%
3.	TDS, mg/l	15300	14968	2.17%	7971	2157	85.90%
4.	BOD, mg/l	8500	3765	55.70%	2443	579	93.19%
5.	COD, mg/l	26500	10695	59.64%	9000	4950	81.32%
6.	TKN, mg/l	800	484	39.5%	327	204	74.5%

results indicate that very less removal efficiency of TSS and TSS occurs in the conventional mode, which would not meet the norms required for disposing into the water bodies. In the novel treatment method, a 50% reduction of the parameters takes place during stage 1 of the air stripping process, and the major part of the removal takes place in stage 2 of the multi-effect evaporator.

5. Conclusion

The pharma industry effluent treated by using conventional methods and multi-effect evaporators is collected on different days and allowed for testing on basic parameters. Based on the test results, it is proved that the multi-effect evaporator has higher removal efficiency compared to the conventional method. The treatment employed using a multi-effect evaporator with the flash mixture and stripping column provides greater efficiency in the removal of TSS, TDS, BOD, COD, and TKN with a removal percentage of 85.57%, 85.90%, 93.19%, 81.32%, and 74.50% than conventional mode treatment. The flash mixture and stripping column should be included in operation before the multi-effect evaporator in order to reduce fouling in the evaporation stages because pharmaceutical-based effluent contains high concentrations of solvents, chemicals, solids, and salts. The removal efficiency of the proposed multi-effect evaporator is very high than that of the conventional mode. The proposed system's designs are becoming a challenge because they include series flash, stripping columns, and evaporation. The selection of the coagulants and flocculants is also challenging in terms of cost-effectiveness and feasibility. The solvent removal from the stripping column becomes waste to wealth. The final treated effluent from this can be directly used for boilers without reverse osmosis.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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