Application of Artificial Intelligence and IoT to Membrane Bioreactor (MBR) and Sewage Treatment Plant

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Abstract A membrane bioreactor (MBR) is a capable treatment technology that consists of an activated sludge process (ASP) emerging with membrane filtration which retains the reduced biomass. MBR is an emerging treatment technology to treat sewage wastewater and reuse the water for various purposes like gardening, toilet flushing, farming, etc. In this paper, a design of the sewage treatment plant is proposed by using MBR technology. To achieve promising and effective results, the traditional design method has been replaced by modern techniques such as wireless sensor networks and the Internet of Things (IoT) software platform to carry out the analysis of sullage wastewater. It concludes that the traditional design system is influenced by the integration of IoT. Further, this paper gives insight into the application of Artificial intelligence (AI) for curtailing the complications in sewage treatment.

Keywords Artificial intelligence · Internet of Things · Membrane bioreactors · Sewage treatment plant · Wireless sensor networks · Wastewater

1 Introduction

Sewage is the wastewater generated by the community of human beings. Around 70% of freshwater consumption is converted into wastewater. Wastewater is contaminated by domestic, industrial, and commercial use that changes its parameters continuously such as COD, BOD, pH, hardness, TSS, etc. Water scarcity is a big challenge to fulfill the per capita demand of the city. Hence, there is an urgent need to treat wastewater and utilize it effectively so that the water demand can be fulfilled. It is observed

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that 99% of water is characterized by the rate of flow of its biological, chemical, and physical factors (BOD, COD, pH, hardness, conductivity, turbidity, acidity, DO, TDS, TSS). The sewage wastewater systems can meet the demand for freshwater in smart cities by treating and managing wastewater with the help of Artificial intelligence (AI) and Internet of Things (IoT) sensors. AI and IoT have several influential and hands-on tools to overcome various complex problems related to wastewater treatment [1]. Nowadays, several researchers have implemented AI and IoT technologies because of convenient operation, high speed, high accuracy, and no issues related to the physical problem [2]. AI implemented for seed, crop, leaf, stem, fruit infection [3]. AI is also applicable for the financial sector to predict financial capital [4]. AI can resolve various practical issues related to various engineering disciplines such as civil engineering, environmental engineering, etc. To improve the quality of wastewater and drinking water AI was implemented [5]. The ground water contamination is detected using AI [6]. AI plays an important role to enhance the quality of water by assessing river water, wastewater recycling and water resource engineering [7]. Further, AI is used to find out the characteristics of saline water and to treat the saline water [6, 7]. To detect the machine fault, AI technology is convenient [8]. AI has application in an integrated vehicle health management (IVHM) for aerospace to identify the primary challenges related to paradigm [9]. The process of removing a contaminant from wastewater and household sewage both runoff and domestics are called Sewage treatment [8, 9]. The sewage wastewater treatment is the significant steps to reduce the pollution and promote the water quality [10]. Sewage is the complex waste affected by microbiological, physical and chemical factors variability which requires appropriate treatment technology to operate the sewage treatment plant [10, 11]. Membrane bioreactor (MBR) has made great attention owning to its very high efficacy and is a capable treatment technology which consists of activated sludge process (ASP) emerging with membrane filtration which retain the reduced biomass [11]. MBRs technology is observed as significant fundamentals of advanced effluent repossession and recycle technology and are comprised in a numeral of prominent schemes worldwide [12]. MBR having energy saving efficiency and footprint over conventional processes such as activated sludge process (ASP) oxidation pond, etc. MBR consists of ASP and a membrane detached method [13]. MBR functioning analogous to traditional ASP, and there is no requirement of sedimentation and filtration identical to slow sand filtration (SSF) [14]. Small pressure membrane purification whichever micro-filtration (MF) or ultra-filtration (UF) were implemented to distinct wastewater from ASP [15]. MBR configuration consists of submerged membrane or external circulation (side stream configuration) [16]. Submerged membrane often applied in municipal wastewater treatment [17]. Submerged membrane bioreactor consists of plate membrane module or hollow fibre [18]. Sufficient preliminary treatment was essential to avoid the clogging (Membrane fouling) [19]. 12–15 g/s is recommended for more concentration otherwise it will lead to the functioning problem and decreased oxygen transfer efficiency [20]. Hydrodynamic condition, type of membrane salient feature of module is highly responsible for the clogging of MBR. Due to the bacteriological digestion molecular weight of present substance may increase [21]. The emerging technology

interacts with active sludge and detached sludge and liquid wastewater [22]. ASP consist of screening aeration, clariflocculator and rapid sand filter but still sludge is generated on a large scale this problem can be solved easily using cutting-edge technology such as membrane bio technology which enhance organic treatment. This technology having scope to degrade the parameters of highly contaminated wastewater, dairy industry, sugar industries food processing industries etc. The technology becoming popular day-by-day due to less space is required for installation, instant operation, very less sludge generation and quality of treated parameters as per the central pollution control board norms.

This process involves physical, chemical, and biological methods that remove respective contaminants also produce clean and safe water. In this paper, IoT and Artificial Intelligence (AI) based prediction models were implemented to monitor the sewage treatment plant.

2 Preparation of Your Paper

Figure 1 shows the location of Imagica STP plant Khopoli-Pali Road, SH 92, Sangdewadi, Maharashtra, India. The layout of the Imagica STP plant has been mentioned in Fig. 2. A row sample of sewage was collected in a container and kept in the refrigerator (Fig. 3). Analysis of sewage wastewater was carried out to find out the characteristics of sewage wastewater (Table 1).

Surrounding is extremely contaminated if industrial waste is discharged without treatment. Portable water is the basic need of human beings. The Maharashtra government treat 22% sewage collected. The remaining 78% row sewage predisposed into

Fig. 1 Site location of STP plant

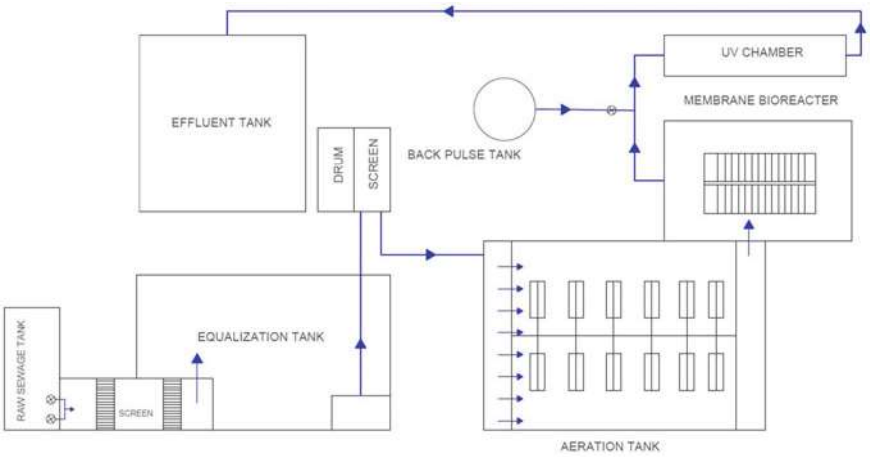

Fig. 2 Flow diagram of STP Imagica Water Park

Fig. 3 Row sewage collection

Table 1 Chemical characteristics of sewage wastewater

S. No	Test parameters of untreated sample	Laboratory result
1	pH value	7.12
2	Electrical conductivity, ds/m	0.631
3	Turbidity, NTU	9.0
4	TDS, ppm	321.4
5	COD, mg/lit	723
6	BOD (at 3 day), mg/lit	192
7	DO, mg/lit	1.42
8	Total hardness as $CaCO_3$, mg/lit	294
9	Total alkalinity as $CaCO_3$, mg/lit	148

waterways which creates chances of water-borne diseases. In India, the government and scientists are facing the problem due to habit of human being to handle the sewage water. To save the environment design, operation and treatment of sludge treatment plant (STP) is the solution.

2.1 Information of Imagica Water Park, Khopoli

See Fig. 4.

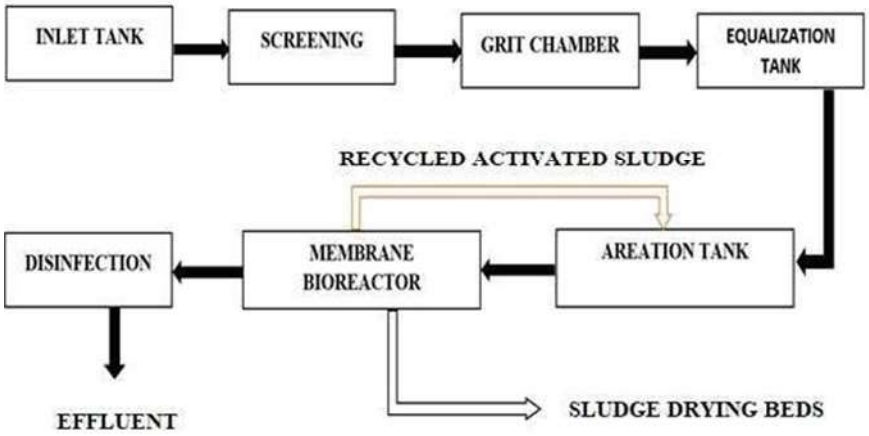

Fig. 4 Sewage treatment plant flow chart

3 Result and Discussions

Membrane bioreactor (MBR) is an advanced emerging technology that can curtail the parameters of sewage such as COD, BOD, TSS, etc. Table 2 illustrate parameter of sewage before and after the treatment. Which shows that treated effluent can be used for various purpose such as gardening, flushing of toilet, etc. The residual sludge can be used as manure for agricultural purposes. Figure 5 shows the quality of effluent and manure.

IoT plays a vital role in the operation, monitoring, and maintenance of sewage treatment plants. To achieve the sustainability of the sewage, plant digital innovations

Table 2 Parameters of sewage before and after treatment

Parameter	Influent (in mg/l except pH)	Effluent (in mg/l except pH)
pH	7.95	7.77
BOD	192	2.70
COD	720	8.18
TSS	321	3.51

Fig. 5 Water quality and manure after the MBR treatment

were carried out which sense the analysis of the collected data, and the operational treatment technology. The programmable logic controllers (PLC), process control station, and optical fiber sensor were implemented to control the operation. Supervisory Control and Data Acquisition (SCADA) method was executed to evaluate the overall functioning of the plant. PLC, remote terminal units (RTU) interpreted the gathered information about effluent characteristics, analyze the real-time data from the connected numerous sensors and transmit it to the field instrumentation. With the help of a real-time sensor and SCADA online monitoring of various parameters of sewage plant were carried out which includes monitoring of pH of effluent, total suspended solids variation during the process. The quality of effluent depends upon the amount of dissolved oxygen present in the effluent. Degradation of effluent is depending upon the microorganism such as aerobic bacteria which consume the oxygen and curtail the parameters of the effluent. Chemical oxygen demand (COD) is the crucial constraints which elaborate the sewage wastewater quality. SCADA application helps to monitor the parameters of COD.

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