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SEWAGE WATER TREATMENT PLANT USING DIFFUSED AIR SYSTEM

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ABSTRACT

Current study was aimed to propose a novel design for compact sewage water treatment plant with a capacity of 100 m^3/day (2x50 m^3/day). The major pollutants are SS, BOD_5, COD and organic pollutants. The recommended treatment process is an aerobic activated sludge. The analysis results of the sewage water are: pH average values 6-8, turbidity 12 UNT, daily suspended solid 850 mg/L, BOD is760 mg/L. The proposed design for the treatment plant consists mainly of: a bar screen, aerated gas trap, aeration tank and a collection pit. The main components of the extended aeration unit are: clarifier, sludge holding tank and diffused air system. The general objective of this investigation is to treat sewage wastewater and produce treated water which coincides with environmental regulations. While the specific objective is to get odourless, colourless treated water free of pathogens and toxic materials so it can be used for irrigation of non-edible trees.

Keywords: aerobic degradation, diffused air system, organic pollutants, sewage treatment.

1. INTRODUCTION

Increasing pollutants in the waste water leads to developing and implementing new treatment techniques to reduce pollutants (1). Sewage and sewage effluents are from the major water pollutant's sources. Sewage is mainly composed of a mixture of domestic wastes including wash-water, human fecal material, and industrial wastes. A sewage treatment plant is quite important to receive the domestic and commercial waste and removes the materials which pose harm for general public (2). Sewage water contains complex organic material mainly consisting of carbohydrates (14%), proteins (40%), lipids (10%), lignin (17%) and ash (30-50%) (3). It also contains vast quantities of bacteria and other organisms (4).

Sewage has been considered a major carrier of disease (from human wastes) and toxins (from industrial wastes). A new regulation concerning the quality of receiving waters has been considered (5).Water from the mains, used by manufacturing, farming, houses (baths, toilets, sinks, showers, kitchens), commercial and hospitals, is reduced in quality as a result of the introduction of contaminating constituents. There are some pollutants have to be removed such as organic wastes, suspended solids, bacteria, nitrates, and phosphates (6).

To accept reusing the sewage wastewater or for returning it to the environment, the contaminants' concentration must be reduced to an acceptable safe level which usually fit the standards set by the Environment Agency.

Sewage treatment is the process which includes different techniques: chemical physical and biological processes to remove contaminants (7).

The aim of sewage treatment is to produce environmentally safe sewage water which is called effluent and a solid waste which is called sludge. Reuse is often for agricultural purposes and sludge is used as a fuel source (8).Aerobic granular sludge (AGS) technology is an upcoming technology for treatment of domestic and industrial wastewater. Aerobic bacteria break down organic matter in the presence of available oxygen (9).

The ability of microorganisms to degrade the organic pollutants is an important feature to the environment and is considered as an effective way for removing contaminants from the polluted ecosystem. Until now, there are only few studies showing the results of aerobic degradation of these compounds (11, 4).

As a result of the high settling tanks are not needed and a reduction ratio of 80% in area use is possible (10). Aerobic granules are characterized by a compact structure form, with no need for the carrier material, resulting in high settling velocities (12). The aerobic treatment of wastewater has many advantages such as process sensitivity, vulnerability, odour problems, long start-up time and also post treatments in order to achieve the required discharge standards (13).

The main objective of this investigation is to develop a least cost design procedure for sewage water treatment systems discharged from Santa Close Resort, Egypt. The study includes design specifications for different equipment and units which aiming to reduce organic pollutants. A system on the basis of extended aeration as a rectangular package sewage treatment plant, with diffused air system has been designed. The sewage water treatment plant is concerned with using microorganisms in the organic pollutants digestion and reducing its hazardous, odourless and stable solids.

2. EXPERIMENTAL TECHNIQUE

The practice of this study is to follow three phases for sewage treatment: pretreatment, primary, secondary then tertiary treatment. In the pretreatment step large solids particles are screened then in primary treatment process wastewater is left to stand to float oil and grease at the surface and solids can be sink to the bottom to form sludge. In secondary treatment sludge is digested for biogas production for electricity generation.

2.1 Design considerations

This research is a case study for treatment of swage wastewater from Santa Close Resort (SCR).

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Collecting samples before and after treatment was analysed and results are shown in Table-1. According to analyses results of collecting raw samples (shown in Table-1) design considerations of treatment plant were suggested and are illustrated in Table-2.

Table-1. SCR sewage water analysis after secondary and tertiary treatment.

Parameter	Before S. Treat	After S. Treat	Tertiary treatment
Average Flow, m^3/day	100 (2x50)		
BOD_5, mg/L	850	44.8	--
pH	6-8	6.8-8.2	--
COD, mg/L	760	40	30
TSS, mg/L	850	30	10
Turbidity, NTU	12	12	≤ 7
Residual Dissolved Oxygen Concentration	2 mg/L		1 mg/L
Residual Chlorine Concentration	1 mg/L		--

Table-2. Design considerations for Santa Close Resort compact plant.

Items	Data
Tank Volume	3.12 m^3
Free Board	0.3 m
Detention Time	16 min. at peak flow
Dimensions	(0.5 m x 1.75 m x 3.5 m) (L x W x H)
Diffusion system material	Carbon Steel Epoxy Coated
Type Diffusion System	Medium Bubble Diffusion

2.2 Technological considerations

In this study a proposed compact plant set-up similar as in the earlier previous studies [14-17], the main difference is using aerated unit (air diffusers) in the biological treatment reactor to remove biodegradable fractions of organic materials. The design of the aeration devices in biological treatment reactors focused on transferring oxygen at a sufficient rate to capture the demand of the biomass and keep the concentration of the dissolved oxygen more than 2 kg/m^3 [18]. Over the years' experience has indicated that 43 – 123 m^3 of air/kg BOD treated are required [19]. So our treatment plant consists mainly of a biological treatment unit, conditioning tank and anaerobic high rate treatment activated sludge unit.

2.3 Experimental procedure

The main components of the treatment plant are suggested as follow:

a. Aerated greased trap,
b. Aerated main lift station/balance tank,
c. Conditioning tank,
d. Bar screen/Splitter box,
e. Extended aeration package sewage treatment:

- A concrete aeration tank and accessories
- A concrete secondary clarifier & accessories
- A concrete sludge holding tank & accessories
- A concrete chlorine tank & accessories
- Diffused air system

f. Anaerobic activated sludge unit.

The above mentioned items have been provided with different pumps categories, storage tanks, air blowers, piping, and control and instrumentation system. The treatment steps are divided into three main consequently process pretreatment, secondary and tertiary treatment steps.

2.3.1 Primary treatment unit

First, the solids have been separated from the sewage by passes through a carbon steel bar screen 25 mm mesh. The sludge is continuously being reduced in volume by the anaerobic process, resulting in a vastly reduced total mass when compared to the original volume which has been entered to the plant. The sludge has been removed when it is about 30% of the tank volume.

2.3.2 Secondary treatment system

The liquid from the primary treatment contains dissolved and particulate biological matter. The flow passed through an aerated gas trap to make the product more digestible, and then the effluence will pass through a conditioning tank.

2.3.3 Tertiary treatment plant

Finally, the sludge is periodically removed by tanker and has been removed for further processing, and the produced treated water may be discharged into a stream, river or it also can be used for a restricted irrigation purposes.

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3. RESULTS AND DISCUSSIONS

The proposed plant design is based on information resulted from analyses of sewage water and experimental data from laboratory and bench scale for the effluent stream. Figure-1 illustrates the process flow diagram for the proposed sewage wastewater treatment plant.

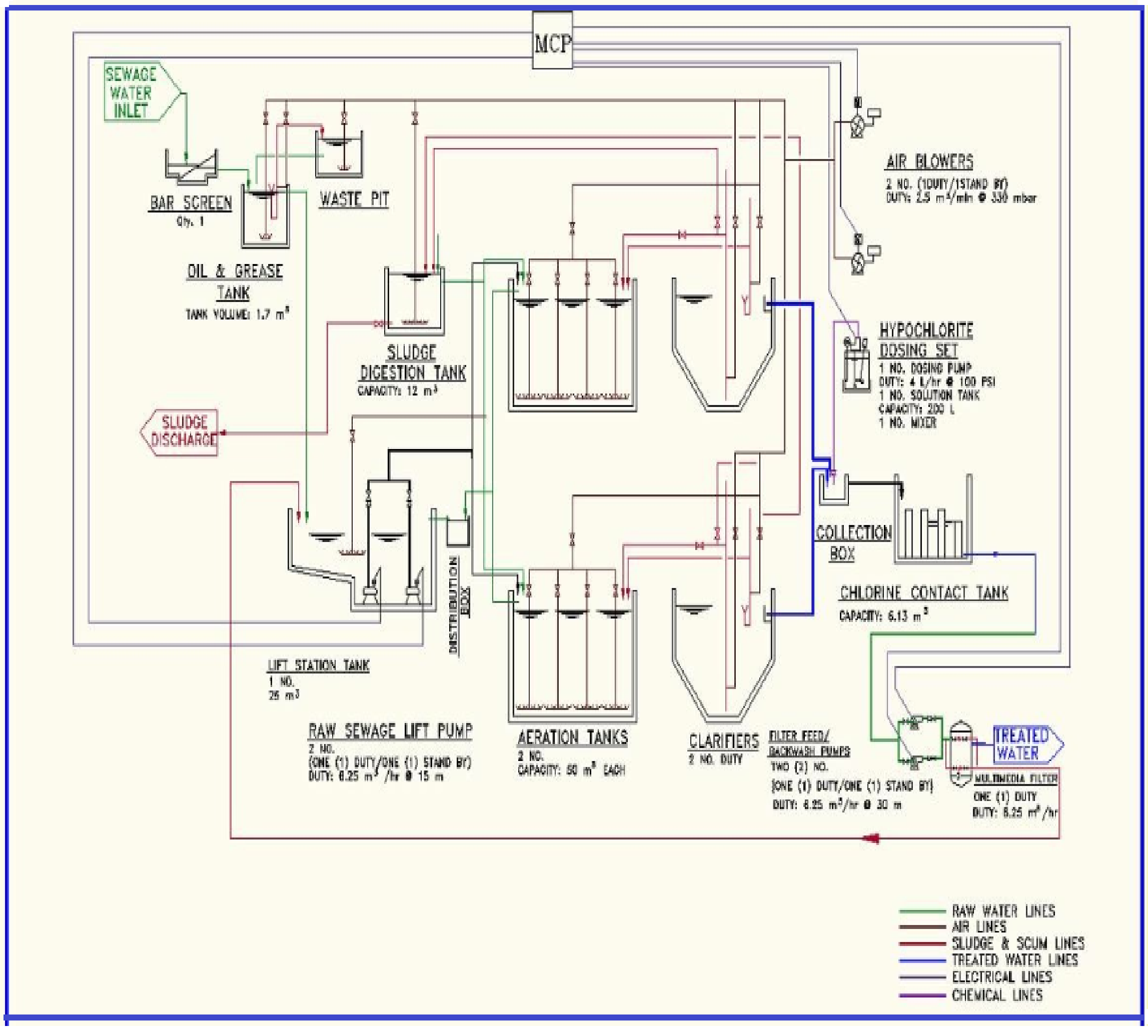

Figure-1. Process flow diagram for the sewage water treatment plant from Santa Close Resort (SCR).

Various components details will be explained in the coming section considering 100 m^3/day (4.16 m^3/hr) of sewage wastewater loaded with 76 kg/day of BOD and daily suspended solids of 85 Kg SS/day as shown in Table (1). Also the effluent after secondary and tertiary treatment has been analysed and the results in the same Table.

3.1 Pretreatment process description

Bar screen/ splitter box

Screening is preliminary treatment processes utilized to aid downstream treatment processes by intercepting unacceptable solids and to alter the physical form of solids so they are acceptable for treatment. Bar screen with a slot width of 25 mm and the screen bars have been made of carbon steel epoxy coated 400 microns and 6 mm thickness.

3.2 Primary treatment process description

3.2.1 Aerated grease trap

Removing grease is essential to the proper functioning of sewage systems. Aerated grease trap with a dimension of (0.5m* 1.75m* 3.5m) has been designed. This unit is composed of a tank with 3.12 m^3, free board 0.3m and detention time 16 min at peak flow. A Medium bubble diffusion system made of carbon steel epoxy coated has been used to supply the air for the mentioned unit.

3.2.2 Aerated main lift station/ balancing tank

The balancing tank is needed to get a wet volume of 25 m^3 with a hydraulic retention time of 6 hours (based on the design feed flow to the reactor).Using two submersible pumps "one in duty and the other is standby" with 6.25 m^3/hr pumping flow and 15 m head.

There shall be furnished and installed submersible pumps. These pumps are suitable for handling untreated sewage, and they are single stage coupled to an electric motor of adequate power, designed to work entirely submerged. Impeller is practically unshakable, and dynamically balanced to suit pump characteristics. Impeller is practically unshakable, and dynamically balanced to suit pump characteristics.

3.2.3Extended aerated package sewage treatment

This system is consists of one rectangular concrete tank with average flow of 100 m^3/day divided into two streams each 50 m^3/d. Dimension of the Sewage Treatment unit Model EXARW-18 is (L*W*H is 14.25* 3.50 *3.50 m). The principal items of the unit include the followings:

3.2.3a Concrete aeration tank and accessories

The aeration zone provides an environment for growth of micro-organisms which convert suspended solids and most of the dissolved solids into bacterial terms. The oxygen required insuring oxidation of the organic matter and growth of microorganisms will be supplied by constantly aerating the contents of the tank. The used aeration tank has a volume 2850 m^3 , free board 0.3 m , retention time 24 hr and dimensions of 2 *(9.0 mx1.75 mx3.5 m) (L.W.H).The aeration basin will be constructed of 30 cm concrete tank, and finished with two coats corrosion resistant coating. The basin wall will be water tight with supporting structural embers when required.

3.2.3b Concrete secondary clarifier tank

Clarifier chamber will be of adequate size to provide a minimum of 4 hours retention, based on the sewage twenty-four (24) hours design flow. The total settling volume will include the volume of the upper one-third of the sludge hopper. The bottom of the chamber will be formed into an inverted pyramidal hopper with the flat bottom. The slope of the hopper walls will not be less than 1.6 vertical to 1.0 horizontal. The clarifier will be equipped with air lift pumps to return the settled sludge and the floating materials to the aeration chamber.

The used clarifier tank has a volume 0.3 m^3, free board 0.3 m, retention time 4 h and dimensions of 2 *(1.75m x 1.75m x 3.5m).

3.2.3c Aerobic Digester

A tank with a volume of 10.72 m^3 and dimensions of 2 *(1.75mx 1.75mx 3.5m) has been used.A sludge holding tank will be furnished for sewage treatment plants with a capacity as indicated on the drawings. The tank shall be constructed of the same material as the plant and conform the same specifications. The tank shall be furnished with all necessary equipment, to achieve a diversion of sludge discharged from the aeration tank to the sludge holding tank by Means of the blowers serving the plant. A supernatant waste pipe shall be supplied to return the supernatant liquor to the aeration chamber.

3.2.3d Integral chlorine contact / balance tank

An chlorine with a volume of 10.72 m^3 and dimensions of 2 *(1.75m x 1.75m x 3.5m) has been used. Chlorine contact tank will be furnished as an integral portion of the Package Sewage Treatment Plant with a capacity and detention time as indicated on the drawings. The tank shall be constructed of the same materials as the plant and conform to the same welding and painting specifications. The tank shall be furnished with all necessary baffles to insure a positive mixing of the chlorine and secondary effluent, and to prevent short circulating.

3.2.3e Chlorination System Equipment

This system is composed of three main parts: chemical pump (4 l/hr and 100 PSSI maximum injection pressure), solution mixer (speed 1500 RPM) and polyethylene tank w/cover (200 L capacity).

3.2.3f Diffused air system

Compressed air is continually diffused into the sewage as it flows through the aeration tank. This provides both a source of oxygen for aerobic bacterial floc that forms in the tank and the turbulence necessary to bring the waste and the bacteria into contact. Aerobic bacteria attack the dissolved and finely divided suspended solids not removed by primary sedimentation. Some of the floc is removed with the sewage that flows out of the aeration tank and carried into the secondary settling tank. Settle to the bottom of the tank, and is later pumped back into the aeration tank. This system is composed of 28 air diffusers (24 for aeration tank + 4 for aerobic digester, 19 mm (3/4 inch) coarse base size) and two blowers(one duty, one stand by, motor speed 1800 RPM, head 400 mbar and flow 2,5 m^3/min).Air to each tank shall be supplied by means of two positive displacement blowers of sufficient size to provide the air required for the aeration chamber and for the air lift pumps.

The diffusers spacing and air velocity shall insure that adequate mixing velocities are maintained. The air diffuser assembly shall be easily removable form the tank and will be equipped with an air-regulating valve to permit either adjustment of the air flow or complete shutoff. Blower assembly will be supplied complete with base, motor, coupling, inlet and outlet silencers, and control valves and complete as requested in the technical specification received from the client.

3.3 Tertiary treatment

The influent from the secondary treatment is passed to the tertiary part of the system. For this purpose, a dual-media filter and feed/backwash pump have been used with the following specifications:

3.3.1 Feed / Backwash pumps

The pump has capacity 10 m^3/hr, head 30 m and speed 2900 RPM.

3.3.2 Dual-media filter

- The incoming wastewater is sprayed over the filter with using a rotating sprinkler. In this way, the filter media goes through cycles of being dosed and exposed to air.
- A vertical dual media filter has been used. The tank diameter 125 cm and tank height 200 cm and a surface flow rate is 6.25 m/hr, backwash flow is 25 m/hr and the material of construction is Carbon steel epoxy coated.
- The used filter consists of: air relief valve, hand-holes, structural legs, internal piping, filter face piping and valves, pressure gauges and lifting eye.

3.4 Irrigation system

Irrigation system consists of two main components:

3.4.1 Irrigation pumps

Two (one duty and one standby) with a capacity 20 m^3/hr, head 20 m and speed 2900 RPM.

3.4.2 The irrigation tank

Reinforced concrete tank with a capacity 100 m^3 and dimensions is 15.48m* 2m* 3.5m.

3.5 Electric control panel board

A weatherproof automatic electric control panel to house the electrical controls of the STP plant and to consist of selector switches, starters, indicating lights and main circuit breakers, all pre-wired tested for immediate connection at site and earthling system includingdeep rods, connecting cables, concrete pits, transmittal cables and marshalling bus bar.

4. CONCLUSIONS

From the previous results it is concluded that:

- Aerobic sludge treatment is an efficient process to reduce organic pollutants over 90% and converted to biogas.
- Aerobic treatment system allows moderate investment with very low or negative operating cost, depending on the amount of biogas produced from this system.
- An environmentally safe stream is produced so after tertiary treatment and effluent specifications are BOD $\leq$ 10 mg/L, COD $\leq$ 30 mg/L, SS $\leq$ 10 mg/L, turbidity$\leq$ 7 NTU and residual dissolved oxygen concentration $\leq$ 1 mg/L.
- Treated wastewater is colourless, odourless, and free of pathogens and toxic materials.
- The treated water with the above characteristics can be used for restricted irrigation, like forest irrigation.

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