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Performance Evaluation of Oxidation Pond for Municipal Wastewater Treatment

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Abstract: This study focuses on the remedial measures suggested to treat collected wastewater at the existing treatment plant in Nandurbar city. The existing Treatment technique is a good option, but irregular operation and maintenance of STP plants and machinery cause damage. So, recycling and reuse of wastewater is the need of the hour today. Oxidation ponds easily provide permissible limits of effluents with the help of proper design.

Oxidation ponds were designed to treat 2.0 MLD of wastewater collected at existing C-Tech basins of the STP plant. The design population is about 1,11,174 people in nandurbar city. A design temperature of 20^0C was adopted for the operation of a pond. As per design considerations, the size of Ops with five units of the pond is 126.49 x 63.24 x 1.50 m. Design depths vary for anaerobic ponds, facultative ponds, and maturation ponds are 1.5 m, 2.0 m, and 3.5 m. The pond design is based on the BOD loading rate, which depends on Temperature (20^0 C) and the pond depth is 1.5 m. The OP requires a standard detention time of 2 weeks to 6 weeks. In this design, the pond volume is 60000 m^3 and requires 30 days of detention time. The chemical analysis on selected parameters BOD, COD, and TSS showed a significant percentage reduction up to 80 %-85 % in affluent content.

The study was conducted by collecting effluent samples from existing treatment plants' outlet stations and taking them for laboratory tests at regular intervals. Samples were conducted weekly with all precautionary measures taken while collecting samples by the grab sampling method. As a result, 40 no. of tests were performed to analyze selected chemical parameters, and the results obtained are pH is 3.0 to 9.0, BOD is 82 to 100 mg/l, COD is 302.43 to 202.43 mg/l, and TSS is 124 to 150 mg/l. After analysis of obtained test results compares those results with standard values of effluents discharged from the treatment plant and oxidation pond. After this analysis, it was observed that we could use an oxidation pond as a good option for the tertiary treatment method for wastewater treatment. OPs provide satisfactory results in removing chemical parameters like BOD, COD, TSS, pH, NH_4, P, S, and Total Coliform.

Keywords: - Oxidation Ponds, Wastewater Reuse, Agriculture, Removal Efficiency, Biochemical Parameters, Effluents.

Introduction: The concern is to improve river health and effectively use treated wastewater for irrigation without causing health issues for the people dependent on it. However, there are some issues with the regular operation of these STPs and their effluent discharge standards. Untreated municipal wastewater is the most hazardous to water ecosystems due to its many nutrients and organic content. Various techniques are used to treat municipal wastewater, which is classified into two groups conventional and non-conventional treatment plants. Conventional treatment plants require high energy, as well as they are expensive, and vice versa. On the other hand, non-conventional treatment processes are low-cost, eco-friendly, and fully depend on the natural purification process.

The conventional wastewater treatment systems include activated sludge, trickling filters, and aerated lagoons, and non-conventional systems include constructed wetlands and oxidation ponds. Oxidation ponds are also known as waste stabilization ponds. Oxidation ponds are biological treatment systems. Processes and operations depend highly on environmental conditions such as Temperature, wind speeds, and light intensity, which are highly variable.

There are many advantages of using the oxidation pond as a treatment method like simple to operate, low energy requirements, less maintenance, and better sludge thickening. However, the effluent quality from the fixed-film system is relatively poorer than that of suspended growth systems in biochemical oxygen demand and suspended solids. Nevertheless, if pond systems are correctly designed and operated, those systems would effectively remove waterborne organic wastes and help reduce some of the problems associated with treating and disposing wastewater.

This study was conducted to properly design guidelines for installing an oxidation pond in Nandurbar city at the existing STP near Nalawa village, which can be a better preventive measure against river pollution and public health. Study shows that attempts have been made to study the performance of the Oxidation pond in respect of different physical and chemical parameters after the treatment process is done. The project aims to utilize treated wastewater for risk-free agricultural practices for nearby farm cultures. Also, there are various other ways of reusing treated wastewater which are as follows: Agriculture, Farm Forestry, Horticulture, Toilet flushing, Industrial and commercial, Fish culture, Indirect recharge of impoundments, Other uses: Subway washing, Coach cleaning, and water for building construction are being practiced, and treated sewage sprinkled on the water-retentive pavement can store water inside paving material, which reduces the surface temperature.

Problem Identification

Restoring the Patalganga river is a must as the river stream gets polluted due to the discharge of untreated wastewater.

Figure 1 Sewage Treatment plant of capacity 17.5 MLD of Nandurbar City (SBR)

Figure 2 Untreated wastewater at the discharge point of the plant

Objectives

- Characterization of wastewater.
- Assessment of oxidation ponds efficiency for treatment of wastewater collected STP.
- Cost analysis of various treatment techniques with the oxidation pond technique.

Literature Review:

Water availability and uses in India:

R Kaur et al. (2012), India accounts for 2.44% of land area, 4% of world water resources, and 16% of the world population. One thousand one hundred twenty-two billion Cubic meters (BCM) is the total useable water resource in the country, which is just 28%

of the water utilized from precipitation. Now 85% of water is diverted for irrigation, and by 2050 it may increase. The Government of India estimates that the total water demand across all sectors in India will rise from 813 BCM in 2010 to 1093 BCM in 2025 and 1447 BCM in 2050. Annual groundwater recharge is 432 BCM, used for domestic and industrial irrigation. With the present population growth rate, the population is expected to cross the 1.5 billion mark by 2050. So, it's urgent to improve water resource management and increase the use of recycled wastewater.

Wastewater production and treatment:

In India, sewage generation is estimated as 72,368 MLD (as per CPCB 2021). The installed treatment capacity is 31841 MLD (43.9 %) and out of 31,841 MLD operationalized capacity is 26,869 MLD (84 %). Actual utilized capacity is 20,235 MLD (75 %) out of operational capacity. It is because of the lack of infrastructure for the conveyance system. 321 STP are based on Activated Sludge Process (ASP), and 490 STPs are designed on SBR technology. Apart from conventional treatment technologies, STPs based on natural treatment systems are also there all over the country. 61 STPs are based on oxidation pond, and 67 STPs belong to the Waste Stabilization Pond system category. As a result, although the sewage treatment capacity in the country has increased three times, hardly 10% of the sewage generated is treated effectively. At the same time, the rest is being discharged into the natural ecosystems, which are responsible for the large-scale pollution of rivers and ground waters.

Ekta Banik and Rishav Singh (2020) have studied the analysis of wastewater treatment in India. The focus is on wastewater generation, treatment, and its uses in India. As per CPCB findings, the following process is followed by these plants for treating wastewater

(i) Aeration- Aeration is the process in which water is brought in intimate contact with air. The gas exchange rate to and from water is governed by 'Henry's Law".

(ii) Coagulation and Flocculation: It is the process in which coagulants are added and followed by gentle mixing to allow the formation of flocs.

Coagulation is when certain chemicals called coagulants are added to water to neutralize the negative protected charge present over them to increase the opportunity to come in contact with each other.

It has aspects- Addition of coagulants, Fast or rapid mixing.

Flocculation- In this process, the neutralized particles are brought in contact to promote their' agglomeration.' Floc formation by inducing slow or gentle mixing. The principle in the flocculation process is the same as in the coagulation process.

(iii) Sedimentation and filtration:

Sedimentation is the natural process by which suspended solids are settled in the tank by the simple action of gravity. The sedimentation theory is based on particles' size and specific gravity.

Filtration can effectively remove turbidity, color, micro-organisms, iron, manganese from aerated water, precipitated hardness from chemically softened water, scum particles (GS < 1), etc.

(iv) Backwashing of filters: maintain the porosity of the bed. Backwashing is required from time to time.

(v) Disinfection: Disinfection of a potable water system is the specialized treatment removal of organisms to avoid the risk of causing disease. For such disinfection, the chemical that has been predominantly used is chlorine, and also it can be done with different methods like boiling, UV rays, treatment with ozone, etc.

Wastewater disposal

Inadequate capacity for wastewater treatment and adding sewage generation pose big questions about wastewater disposal. It is estimated that about 73,000 ha of peri-urban farming in India is subject to wastewater irrigation. In peri-urban areas, growers generally borrow time-round, ferocious vegetable product systems or another perishable commodity like fodder and earn up to 4 times further from a unit land area than freshwater. Major crops being rinsed with wastewater are Cereals, Vegetables, Flowers, Avenue trees, and fodder crops. On the other hand, non-conventional treatment systems like constructed washes need lower material and energy, are fluently operated, have no sludge disposal problems, and can be maintained by unskilled workers fluently. In addition, these systems have lower construction, conservation, and operation costs, driven by the natural powers of the sun, wind, soil micro-organisms, shops, and creatures.

Angelakis, et al. (1996), Wastewater Reclamation and Reuse. Some Genera observations are based on the existing water reclamation and reuse projects: Public acceptance is important. It is essential to prove that reclaimed water is safe concerning chemical and microbiological quality. Monitoring a water reuse program is essential. The precautionary principle should be applied wherever needed to deal with unknown components. Additional safeguards should be applied based on risk assessment and risk minimization.

Conventional wastewater treatment techniques - Sequential Batch Reactor

Sunil S. Mane and Dr. G. R. Munavalli (2015), According to the author, wastewater treatment is a major issue concerning environmental pollution. The SBR is one of the good options for industrial wastewater treatment. The general working steps of SBR are filled, react, settle, decant, and discharge. The nature of SBR is very flexible, so the modification process is easy. The cycles, hydraulic retention time, and sludge retention time may be changed; hence, it provides huge scope for treatment in a single reactor, which is the most advantageous factor.

Lin S.H. & Cheng K.W. (2001) have studied municipal sewage treatment with coagulation as a first process. This study tried a different design for the SBR process reactor, which allows nonstop inflow of sewage wastewater. The steps for SBR are retained batch-wise. In addition, the perforated baffle plates are provided to minimize the influence of the nonstop in-flowing sewage wastewater on the "settle" and "draw" operations of the SBR process. The comparison of the results of the modified SBR is done with conventional SBR and concluded that modified SBR gives the same results and also the advantage is it gives continuous flow. The BOD and COD removal was 91.8 % and 93.6%, respectively.

Wisaam S. Al-Rekabi et al. (2007) reviewed Sequencing Batch Reactors. This paper gives an idea about the different types of methods for wastewater treatment. This technology has become popular throughout these years because of its single-tank design and ease of practice. The review shows this technology's efficiency and flexibility; different effluents such as municipal, domestic, hypersaline, tannery, brewery, and dairy wastewater; landfill leachates; etc.; can be treated through this treatment process under different conditions. In addition, this paper includes related experiments carried out at the laboratory, pilot plant, and industrial scales.

Non-conventional wastewater treatment techniques: - Oxidation Ponds

Erick Butler et al. (2015) According to the authors, oxidation ponds can provide feasible treatment technology in small areas and developing countries because of their less expensive maintenance and simple design. However, the two recommendations need to be considered for expanding this treatment technology. The first is determining how the treatment efficiency relates to the corresponding treatment standards for effluent reuse. Retrofitting current infrastructure and adding stations for fuel production is the second recommendation to provide a return on investment when transitioning oxidation ponds used for larger communities.

Waste stabilization ponds are treated using a single pond to handle treatment or a multiple pond system. The system treats the city's wastewater which is used for irrigation. In a series arrangement, wastewater is treated in the original and posterior ponds and polished in the final pond. On the negative side, wastewater inflow is unevenly divided in the pond arrangement. Each multiple pond arrangement has its advantages, and thus a driver can change the pond arrangement depending on the situation. For illustration, ponds operating in parallel help interrupt treatment during the cooler months of the time. It is when a pond can witness low natural exertion. Low natural exertion can produce anaerobic conditions within a pond. In addition, the operation of ponds in parallel can reduce problems related to periodic low dissolved oxygen attention, particularly in the morning. Nonetheless, applying multiple ponds is more effective for treatment than a single pond.

Dr. Mohammed Ali I. Al-Hashimi and Hayder Talee Hassan (2014), Authors conducted experiments with a model of two ponds in series. First, the pond with aeration process to the aerobic pond was added to the series as a second case to improve the effluent. Then, at last, the sand filter was used to improve the final effluent from the aerobic pond. All three ponds had the same surface area (5.75m*2m) but with different depths, such as 2m, 1.5m, and 0.75m for the anaerobic pond, facultative pond, and for aerobic pond, respectively. In the experimental work, a sand filter was used for algae removal. Sand filter improved final effluent by decreasing total suspended solid and increasing removal efficiency of BOD and COD.

Table 1 Experimental analysis of Oxidation Ponds (mg/l)

BOD	COD	TSS	NO_3	NO_2	NO_4
39.5	112.67	72.67	48	0.02	0.5

Hamzeh Ramadan and Victor M. regarding authors Disposals of BOD greater than 90%, nitrogen junking of 70-90%, and total phosphorus disposals of 30-45% are fluently attainable in a series of well-designed ponds. WSPs can attain a 99.999% fecal coliform reduction when operated in parallel and attain a 100% junking of helminths, easing the recovery of the wastewater for husbandry in both defined and unrestricted irrigation. The removal of BOD in primary facultative ponds is generally in the range of 70-80% based on unfiltered samples and generally above 90% based on filtered samples.

Long T. Ho et al. (2017), From a case study on all four approaches, it appeared that rules of thumb are no longer a proper tool for pond designs due to their low design specification and veritably high affair variability and query. On the other hand, in the morning phase of the design process or in case of low pressure over land and moderate water quality needed, mechanistic models showed their capacity to generate more accurate and effective designs but still need to overcome their lack of estimation and confirmation and over-parameterization.

Table 2 Influent characteristics and effluent standards applied in the case study

Parameters	Unit	Avg. Influent Properties	Effluent Standards
OD	$g\ O_2.m^{-3}$	900	125
BOD	$g\ O_2.m^{-3}$	360	25
TN	$g\ N.m^{-3}$	67	10
TP	$g\ P.m^{-3}$	4	1
TSS	$g\ TSS.m^{-3}$	600	35

Facundo Cortés Martínez et al. (2014), according to authors' conservation, is simple and stabilization ponds are easy to operate. The treatments are recommended in developing countries as they are carried out naturally. The main disadvantage is the system requires a large land area. This study focuses on optimizing a facultative pond, considering a fine analysis of the traditional system to determine the model constraints. Before applying the optimization system, a facultative pond with the traditional method was designed. Both analyses meet the treated water quality conditions for the discharge to the entering bodies. The results show a reduction in HRT by 4.82 days and a drop of 17.9 percent over the conventional system. The analysis of the fine mathematical model is included.

Kiomars Sharafi et al. (2012), Reusing treated domestic and raw municipal wastewaters as a valuable water source for various purposes, including farming and irrigation of recreational areas, is one of the most important motives for wastewater treatment and prevention of water resources, especially in rare water sources. According to the report, removal efficiencies of all parameters except COD in stabilization ponds are higher than those in the activated sludge. In addition, effluent quality in both plants met agricultural effluent reuse standards given all studied parameters except total coliform.

Ashutosh Kumar Choudhary et al. (2011) suggested that constructed wetlands have great potential for treating wastewater. These systems consist of channels planted with helophytes, which depend upon chemical, physical, and biological methods to remove contaminants from wastewater. CW are classified into two categories surface flow and subsurface flow. Both the systems are suitable for removing phosphorus, nitrogen, BOD, COD, TSS, and metals from domestic and industrial wastewaters. This technology act as a natural and low-cost treatment facility for wastewater.

NC Tharavathy et al. (2014), In India and most of the tropical parts of the world, where sufficient sunlight and Temperature are available, the oxidation pond system is most suitable for treating domestic sewage and trade waste-containing nutrients. However, when these pollutants are collected in the sediments of the oxidation pond, they become toxic to the entire oxidation pond community. In addition, these pollutants circulate in a pathway similar to nutrient cycles in the oxidation pond medium. If the pollutants are overloaded in the sewage, they cause shock loads and degrade the effluent quality.

Hafiz Qasim Ali et al. (2017), the treatment efficiency of the sewage stabilization ponds at Chokera, Faisalabad was carried out concerning parameters BOD5, COD, pH, Turbidity, TS, TDS, Copper, Lead. Parameters to finding were monitored at six different locations. The testing was done from December 2015 to January 2016 at The University of Lahore, Pakistan. Environmental

Engineering Laboratory, Department of Civil Engineering. The BOD5 removal efficiency of the treatment plant was found to be 30.08 ties against the designed value of 90% removal. The removal efficiency of COD, TS, TDS, pH, Turbidity, Lead, and Copper was found at 36.56, 22.43, 30.40, 3.43, 73.50, 34.13, and 41.15%, respectively.

C.C. Egwuonwu et al. (2012), According to the report on the design, construction, and performance evaluation of an oxidation pond. The OP comprises one facultative pond and three maturation ponds, all in series. The influent of the WSP after filtration through the lined sandy loam media had the BOD reduced to 22 mg/L from 356 mg/L indicating a 93.8% removal level. A fecal Coli form count of the influent sample gave 1×108 FC/100 mL, whereas the effluent gave ten FC/100 mL, which was 99.9% FC removal. Therefore, the value of 150 mg/L of Total Suspended Solids for the influent was reduced to 26 mg/L for the effluent after treatment. It was concluded that the effluent from the WSP was within the limits of The Federal Environmental Protection Agency standard of 30 mg/L for TSS, 30 mg/L for BOD5, and 400 FC/100 mL for fecal coli form, thus making the wastewater safe for discharge into surface water as well as its use for irrigation after treatment.

Rousseaua et al. (2008) Treated wastewater can be reused for restricted or unrestricted irrigation of crops, toilet flush, golf courses, watering gardens, and public parks, depending on its quality. The large land areas are also required at big city land price more costly, so it is not suitable for the large city it suitable for rural area and low population city. Its main advantage is operation and maintenance costs low and require less skilled labor. Well-designed and operated, constructed wetlands can be adopted at slightly low costs, and treated wastewater suitable for reuse.

Manoj Yadav and Dharmendra (2014), Recycling and Reuse of sewage water is an emerging field attracting new research to develop new technologies to overcome this rapidly growing water crisis. Provision of wastewater reuse leads to sustainable growth, thereby helping to reduce water scarcity and sewage production. However, it must be ensured that the treated water should be regularly monitored and safely supplied. Detailed literature research of two important chemical & biological processes used in wastewater reuse systems has been done here, and their effects are found.

Dr. Timothy Nnaemeka Adibe, and Dr. Samuel Ekene Ugwuanyi' (2019), study shows that the oxidation pond was designed to treat 1043500 m3 day-1 of wastewater generated from classrooms hostels, and staff quarters. The research revealed that ponds could reduce most of the organic pollutants appreciably. The pond has a retention of 13 days, during which the influent BOD, 232.31 mg/l, reduces to 474.4mg/l in the effluent, thus meeting the standard value. Maturation pound has a retention time of 20 days for complete decomposition, and this time is enough to reduce the fecal coliform, which falls within the acceptable standard.

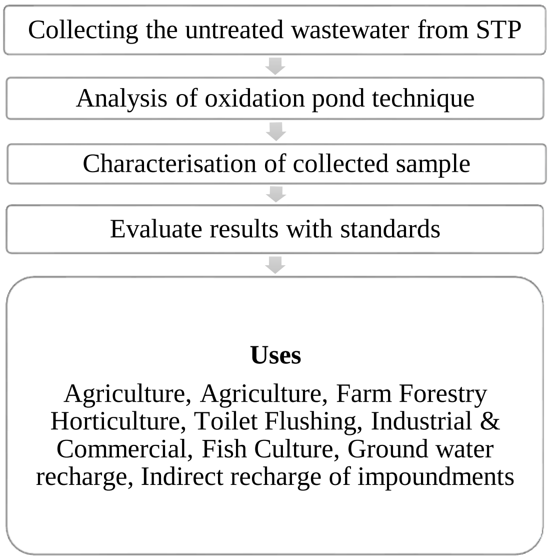
Study Area

Nandurbar is a Municipal Council city in the district of Nandurbar, Maharashtra. Nandurbar city is situated along the right bank of the Patalganga River, an important tributary of the Tapi River. Nandurbar Municipal Council was established in 1998 with an area under a limit of about 11.45 sq. Km. However, on 1st July 1998, Nandurbar Municipal Council came into existence, accommodating six nearby tehsils. Now the area under the municipal council limit is about 32.64 sq. Km. The Nandurbar city is divided into 33 wards for which elections are held every five years. The Nandurbar Municipal Council has a population of 111,037 as per a report released by Census India in 2011. Nandurbar Municipal Council has total administration of over 20,904 houses to which it supplies basic amenities like water and sewerage.

Area of concern

The objective of analysis in the current study in the Nandurbar context is to determine the arising problems with pollution of river Patalganga in the context of wastewater disposal, use, and its adverse impact on the environment and people. This irregularity of wastewater disposal has been used to suggest that a change in the existing wastewater treatment and reuse scenario practices is essential.

Methodology



The procedure of Sample Collection

- All the samples are collected in the presence of authorized Local Authority personnel.
- All the Samples must be carried out taking due care to avoid any personal injuries or injury arising from the location of the sample point.
- Sample containers are cleaned and well labeled. The date and time of the collection sample, including related location details, were noted carefully.
- Sample bottles are sealed and stored securely for safe transport to the laboratory.
- All the Samples are analyzed within 24 hours of sample collection.

Investigation of Physical and Chemical Parameters

Odor: - The sample gives a pungent smell which shows that it contains toxic substances. The threshold odor test does the odor intensity.

Color: - The collected sample is dark brown and black. Fresh sewage is normally brown and yellowish but over time becomes black, which results from the presence of natural metallic ions such as Fe or Mg, humus and peat materials, planktons, and weeds.

Turbidity: - Due to suspended solids in wastewater, wastewater samples are had higher turbidity. It is caused by six suspended matter such as clay, silt, finely divided organic and inorganic matter, and soluble colored organic compounds. The standard method for determining turbidity is the Jackson candle turbidity meter and Nephelometer.

Chemical Parameters

- Ph. of the sample
- Biochemical Oxygen Demand
- Dissolved Oxygen
- Total Suspended Solids

These tests were conducted when the existing wastewater treatment plant was properly working and the wastewater treatment was good. Samples are collected at the outlet points and taken into laboratories for testing.

Design Equations for Oxidation Ponds

Anaerobic Pond

Volumetric BOD loading (λv) is given by:

$$\lambda v = \frac{Li\ Q}{Va} \qquad \text{(Equation 1)}$$

Q is the wastewater flow (m^3/d), and Va is the anaerobic pond volume (m^3). Li is the BOD of the raw wastewater (mg/l = g/m^3), The standard range of λv is 100 g/m^3d at temperatures ≤10°C, increasing uniformly to 300 g/m^3d at 20°C and then more slowly to 350 g/m^3d at 25°C and above.

The design temperature is the mean Temperature.

When temp. As known, the value of λv is calculated, and then the value of Va is calculated.

The anaerobic pond area is then Find out by dividing Va by the pond depth.

BOD removal is 40% at temperatures ≤10°C, increasing linearly to 70% at 25°C and above.

a) Facultative ponds

The surface BOD loading (λs, kg/ha d) is given by:

$$\lambda s = \frac{10 Li\ Q}{Aaf} \quad \text{(Equation 2)}$$

Where Af = facultative pond area (m^2). The value of Af is calculated.

The value of λs depends on the design temp.,

$\lambda s = 350 \times (1.107 - 0.002T)^{T-25}$

The value of λs is found for the design temp. And Li = BOD of the anaerobic pond effluent (mg/l)

Minimum retention times Criteria.

Mean HRT (θ, days) in an individual WSP is calculated by

$$\theta = \frac{V}{Q} \quad \text{(Equation 3)}$$

Where V = Volume of Pond (m3), Q = flow of wastewater through the pond (m3 /d), A is the pond area (m2), and D is the pond's working depth of liquid present (m).

The minimum design retention time is one day in anaerobic ponds, four days in facultative ponds,

and three days in the maturation pond.

If the calculated value of θ in the design is less than this minimum value (θmin), then the pond volume or area is calculated from,

$$V = Q\theta min \quad \text{(equation 4)}$$

$$A = \frac{Q\theta min}{D} \quad \text{(Equation 5)}$$

Land Area Requirements Standards

The land areas required for anaerobic and facultative ponds can be calculated, which may be very beneficial during the planning when land availability and price are to be considered as a key factor for a final decision on the type of wastewater treatment chosen.

b) Anaerobic Ponds

The equation can be rewritten as:

$$Aa = \frac{Li\ Q}{D\ lv} \quad \text{(Equation 5)}$$

Where, Li Q - Quantity of BOD, g/caput day, Aa - anaerobic pond area, m2/caput, D - anaerobic pond depth, m, lv as described above

c) Facultative Ponds

The equation can be rewritten as:

$$Af = \frac{10\ Li\ Q}{ls} \quad \text{(Equation 6)}$$

Where LiQ = quantity of BOD, g/caput day, Af = facultative pond area, m2/caput, ls as described above

Note: that the total area calculated (Aa + Af) shall be multiplied by a factor of 1.25-1.5. For the overall land area required, 1.25 factor is used for large systems while 1.5 factor is more used for small systems. When maturation ponds are required, the extra land and area required for building and maintaining these ponds shall be added.

Design of Oxidation pond

Given Data: -

Location – 21.370 N, BOD Loading Rate – 225 kg/ha/d, Temperature – 30^0C max. And 20^0C min.,

Sky Clearance Factor - > 75%, Population-1,11,174, Sewage flow – 108 lpcd, Discharge – 2.0 MLD,

Influent BOD – 85 mg/l, Effluent BOD – 4 Mg/l, K @ 20^0C – 0.1 Bod loading rate – 225 kg/ha/d

Elevation = 210 m.

$H = \frac{210}{100} = 2.10$

Population = 1,11,174 Sewage flow = 108 lpcd

Q = 2.0 MLD

= 2000 m3/d

So = $\frac{85}{1000}$

= 0.085 kg/m^3

S = $\frac{4}{1000}$

= 0.004 kg/m^3

BOD loading Rate = Q x So

= 2000 x 0.085

= 170.00 kg/d

Area of BOD loading rate = 225 kg/ha/d

Correction for elevation = (1+0.003H) = (1+0.003x2.10) = 1.006

Corrected BOD loading rate = $\frac{225}{1.006}$ = 223.65 kg/ha/d

Aerial of BOD loading rate = $\frac{\text{BOD load}}{\text{Area}}$

Area = $\frac{\text{BOD load}}{\text{Aerial BOD loading}}$ = $\frac{170}{223.65}$ = 0.76 ha.= 0.76 x 10^4 m^2

Detention Time

Td = $\frac{1}{k}\ln\left(\frac{So}{S}\right)$

k@20^0C = 0.1 d^{-1}

k@20^0C = k@20^0C x $(1.047)^{T-20}$

= 0.1 x $(1.047)^{20-20}$

= 0.1047 d^{-1}

Td = $\left(\left(\frac{1}{0.1047}\right) \times \ln\left(\frac{85}{4}\right)\right)$ = 29.19 days i.e. 30 days is detention time

Td = $\frac{\text{Volume}}{\text{Flow rate}}$ V = Td x Q = 30 x 2000

V = 60000 m^3

V = A x D

Where, D = 1.5 m (1 to 1.5)

Area = $\frac{60000}{1.5}$ ha.= 40000 m^2 = 4 ha.,

Here we are proposing five units

The surface area of one unit = $\frac{4}{5}$ = 0.8 ha.

Assume, $\frac{L}{B}$ = 2 (L/B > 3)

Area = L x B = 2B x B = 0.8 x 10^4 = $2B^2$

B = 63.24 m.,

L = 2B = 2 x 63.24 = 126.49 m.

Size of Pond = 126.49 x 63.24 x 1.50 m. (Here, we are proposing five units)

Cost Analysis

The cost of a sewage treatment process differs significantly depending on the time and location. Therefore, several methods are available to determine the benefits of installing oxidation ponds. The main costs are construction, operation, and maintenance. Examples of construction costs include construction, land, structures, and engineering fees, while energy is the primary operation and maintenance cost. As per the EPA in the USA, the study concludes that OPs have a lower cost per capita compared to primary & secondary treatment when considering populations between 100 & 100,000.

Furthermore, the study finds that estimated capital costs ranged between $0.20 and $1.00/population equivalent/year (Gloyna 1971).

Table No 2 Construction and operation costs for natural wastewater treatment methods in the USA (Arthur 1983; Varon and Mara 2004)

Sr. No.	Treatment Systems	Construction Cost (Lakhs)	O & M Costs (Lakhs/capita)
1	Waste Stabilization Pond	4520	158
2	Aerated lagoon System	5549	951
3	Oxidation ditch System	3805	1109
4	Biological Filter	6183	634

Capital Cost

The relationship between capital cost and the treatment volume of UASB and WSP systems. Since many researchers use Eq. (3.16) as a general expression between the cost and treatment volume, it is also applied in this study. The relation then appears as

$$y = 494x^{-0.20} \text{ for USAB,}$$

$$y = 474x^{-0.32} \text{ for WSP,}$$

Where y is the capital cost per unit volume, US$/ m^3/d, and x is the treatment volume, m^3/d.

The capital cost of WSP is lower than the other treatment methods.

Annual O & M Cost

The replacement of mechanical and electrical equipment was calculated based on an annual interest rate of 5%. For this study, Eq. (3.16) appears as

$$y = 457x^{-0.49} \text{ for UASB,}$$

$$y = 995x^{-0.71} \text{ for WSP,}$$

Where y is the annual O&M cost per unit volume, US$/$m^3$/d, and x is the treatment volume, m^3/d.

In this study, the cost for UASB appeared much greater than WSP.

Land Requirements

In addition to expressing capital and annual O&M costs, Eq. (3.16) expresses the land requirement as follows:

$$y = 10.4x^{-0.12} \text{ for UASB,}$$

$$y = 326x^{-0.37} \text{ for WSP,}$$

Where y is the land requirement, m^2 per m^3/d, and x is the treatment volume, m3 /d.

The land area for a UASB system was determined to be between 2.0 and 5.1 m^2/m^3/d. Some authors have reported that the land requirements for this system were 1.1–2.0 m^2/m^3/d (Binnie Thames Water, 1996; Arceivala, 1998) and 4.0 m^2/m^3/d (Schellinkhout, 1993). The main STPs with the UASB system facilities are the UASB reactor, pond, and drying beds for sludge treatment, which occupy a large portion of the total area. Generally, the land these facilities occupy increases proportion to the treatment volume.

Results

These tests were conducted when the existing wastewater treatment plant was not properly working, and there was no wastewater treatment. Collected sewage waste is directly discharged into the river Patalganga without any treatment. Samples are collected at the outlet points and taken into laboratories for testing.

In this study, we performed 40 no. of laboratory tests to find various Characteristics of Chemical parameters like pH, BOD, COD, TSS, etc.

- 10 no. of samples collected at weekly intervals for testing above mentioned four parameters.
- Each sample is collected by the grab sampling method with all precautionary measures.
- Collected samples are taken to the laboratory available at the existing sewage treatment plant for the test.

Characterizations of chemical Parameter

1. **pH**

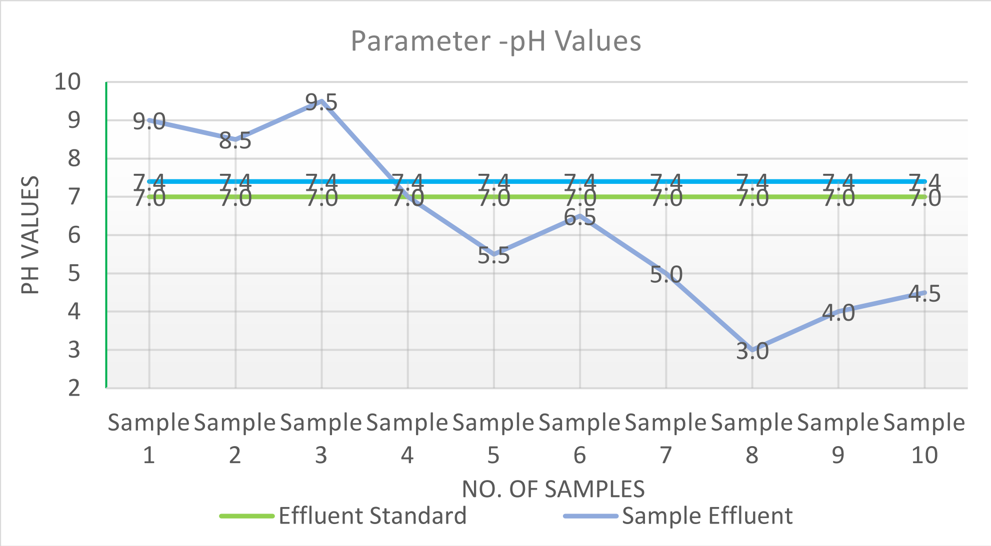


Figure Laboratory test results obtained for parameter pH

- The results from several laboratory tests summarize that the pH value of discharging wastewater from the existing treatment plant is around 3.0 to 9.0, which is not within the acceptable limit. As per CPCB, effluent discharged standards for sewage treatment plants of chemical parameter pH are 6.5 to 9.0.

2. **Biological Oxygen Demand (BOD)**

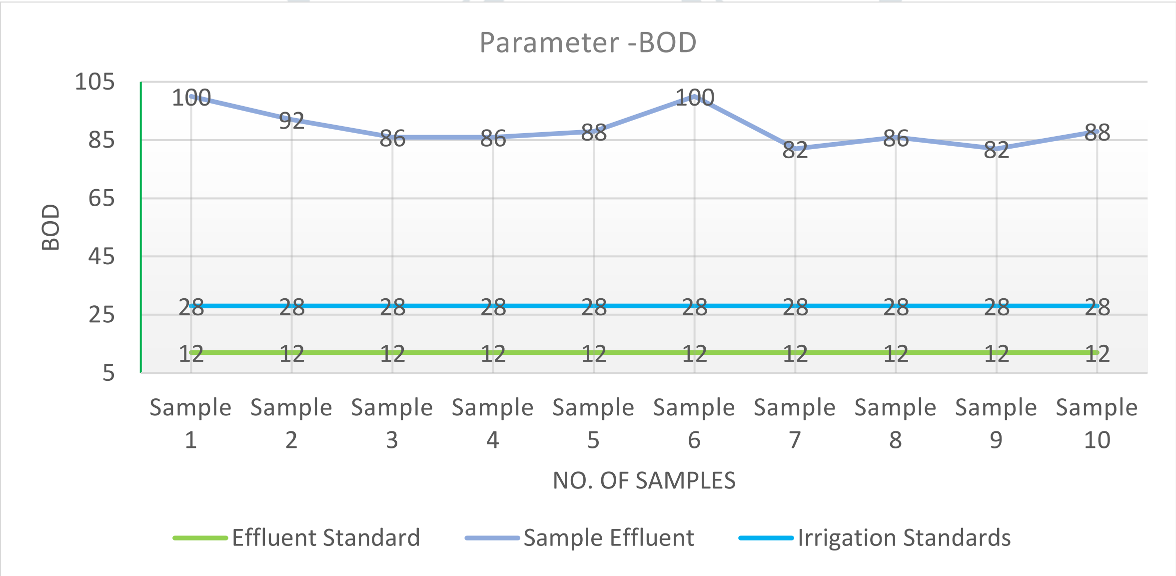


Figure Laboratory test results obtained for parameter BOD

- Above mentioned results show discharging wastewater contains BOD of around 100 to 82 mg/l, which is not within the acceptable limit. As per CPCB, effluent discharged standards for sewage treatment plants of chemical parameter for BOD is not more than 10.00 mg/l.

3. **Chemical Oxygen Demand (COD)**

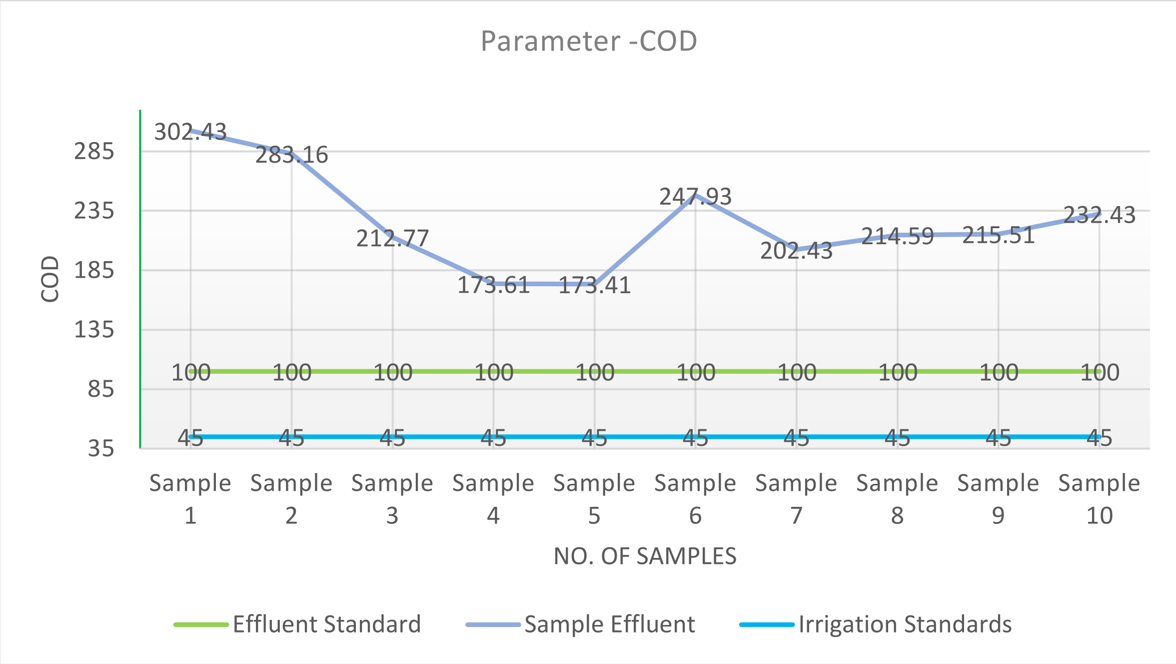


Figure Laboratory test results obtained for parameter COD

- Effluent discharged into river Patalganga contains COD between 302.43 to 202.43, which is not within the acceptable limit. CPCB suggests the COD value for discharging effluent from STP is not more than 50 mg/l.

4. **Total Suspended Solids (TSS)**

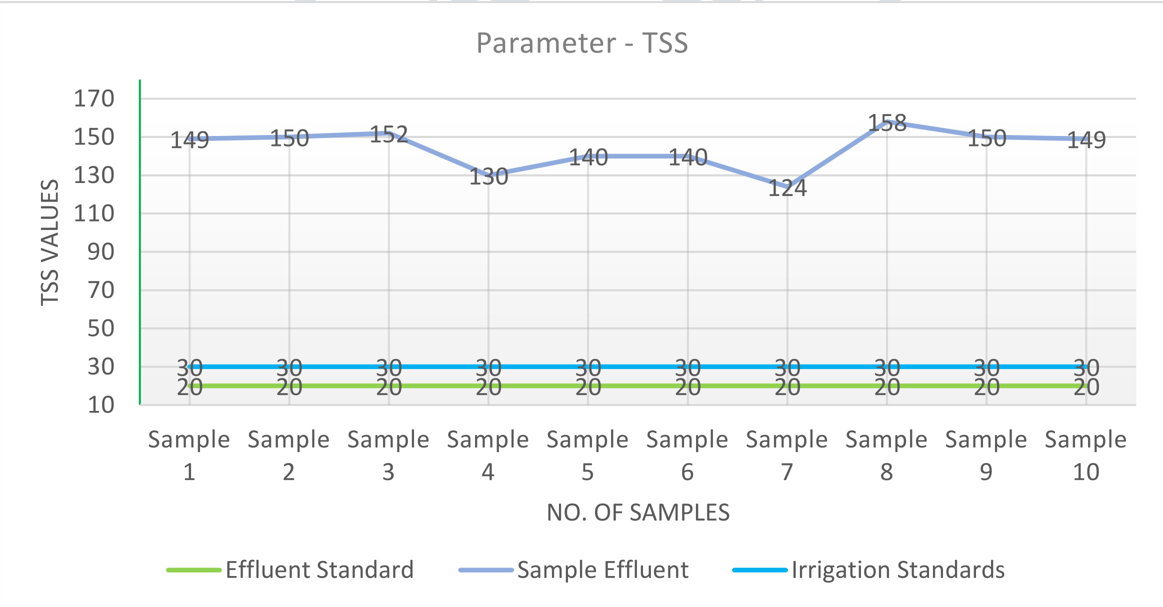


Figure Laboratory test results obtained for parameter TSS

- The above results show TSS value for effluent discharged from Existing STP is around 124 to 150 mg/l. Which also does not come under the acceptable limit. As per CPCB effluent discharged standards for sewage treatment plants, the chemical parameter TSS is not more than 20 mg/l.

Design of Oxidation Pond

- Considering 111174 population-based on (census 2011) and wastewater discharge from existing STP 2.0 MLD. We can provide an oxidation pond system of size,
- Size of Pond = 126.49 x 63.24 x 1.50 m., Here, we propose five units.
- Effluent quality requirement - These effluent qualities can be summarized as follows

Table Comparison of Effluent quality parameters

Parameter	Effluent Values Obtained from Existing STP	Effluent Values Obtained from Oxidation Ponds	Standard effluent Values for Land for Irrigation	Standards for Discharge of Environmental Pollutants from STPs
pH	3.0-9.0	7.4	5.5-9.0	6.5-9.0
BOD	82-100	28	<100	<20
COD	302.43-202.43	100	--	<50
TSS	124-150	30	<100	<20

With the help of Oxidation Pond as an alternative for wastewater treatment at nandurbar city, we can achieve effluents standards easily.

- By comparing those obtained effluent values with oxidation ponds results, we can conclude that oxidation pond is a much more suitable treatment technique for wastewater treatment in such cases.
- The average results obtained from the oxidation ponds treatment method as per authors Dipu Sukumaran et al. (2015) for various parameters BOD, COD, TSS, TC, and FC are 69, 50, 81, 95, and 86, respectively.
- Experimental analysis by author Dr. Mohammed Ali I. Al-Hashimi find out the results of parameters BOD, COD, TSS, NO_3, NO_2, and PO_4 are 39.5, 112.67, 72.67, 48, 0.02, and 0.50, respectively.
- The results obtained by authors Rositayanti Hadisoebroto et al. (2014) for pH, BOD, COD, & TSS are 7.4, 30, 28, & 45, respectively.
- The author Kiomars Sharafi with the help of oxidation pond treatment technique of various parameters like BOD, COD, TSS, and total coliforms, are 41, 84, 47, and 3.0 to 3.5, respectively.
- Effluents Characteristics applied in his case study by Authors Long Ho et al. (2017) are COD, BOD, TN, TP, and TSS 125, 25, 10, 1, and 35, respectively.
- As per the results mentioned above, we can say that an oxidation pond can provide an effective treatment technique for wastewater treatment.
- The results of parameters pH, BOD, COD, and TSS, by Oxidation Pond treatment methods, are 7.4, 28, 100, and 30, respectively.

Cost Analysis

- The low-cost treatment processes WSP and UASB in terms of capital and annual O&M costs and land area requirements are compared to the mechanical aerated processes BAF and ASP in terms of costs.
- It has been found that the UASB system requires more capital and O&M costs than WSP. The capital and O&M costs for UASB and WSP systems were expressed by a first-order equation, which other researchers have also utilized. The capital cost for the investigated WSP is considered typical in India since it is similar to the other reports in India (Arceivala, 1998).
- Systems like ASP did not show much benefit in COD removal cost. So, finally, it was found that UASB could be economically the best option for India when considering all factors, including expenses and treatment efficiency.

Conclusion

This study presents a situation of the existing wastewater treatment plant and an assessment of the oxidation pond's efficiency for wastewater treatment and agriculture reuse. After comparing tested results, it is found that the effluent discharge into river streams in current practice is harmful to public health and not useful for agricultural purposes.

1. Characterizations of chemical Parameters

   pH Parameter-The results mentioned above summarize that the pH value of discharging wastewater is around 3.0 to 9.0, which is not within the acceptable limit. As per CPCB, effluent discharged standards for irrigation purposes of chemical parameter pH are 5.5 to 9.0.

Biological Oxygen Demand (BOD)- Above mentioned results show discharging wastewater contains BOD of around 100 to 82 mg/l, which is not within the acceptable limit. As per CPCB, effluent discharged standards for irrigation purpose of chemical parameter for BOD is less than 100.00 mg/l.

Chemical Oxygen Demand (COD)- Effluent discharged into river Patalganga contains COD between 302.43 to 202.43, which is not within the acceptable limit. Therefore, CPCB suggests the COD value for discharging effluent for irrigation purposes from STP is not more than 250 mg/l.

Total Suspended Solids (TSS)- The above results show TSS value for effluent discharged from Existing STP is around 124 to 150 mg/l. Which also does not come under the acceptable limit. As per CPCB effluent discharged standards for irrigation, the chemical parameter TSS is not more than 100 mg/l.

2. From the above-obtained results, we can compare those results with standard effluent parameters decided by Central Pollution Control Board for various purposes and conclude that.

- Nitrogen removal of 70-90%, BOD removal is greater than 90%, and total phosphorus removals of 30-45% are easily achieved in a series ponds system.
- BOD removal in facultative ponds is usually in the range of 70-80% based on unfiltered samples and more than 90% related to the filtered sample.
- The collective performance of anaerobic and facultative ponds is better than a facultative pond.
- Facultative ponds and Anaerobic ponds, when designed as a system, can produce an effluent much more suitable for surface water discharge with fewer land requirements than a regular pond.
- An anaerobic pond placed before a facultative pond will produce effluent quality suitable to be discharged to surface bodies.
- BOD removal is not possible in maturation ponds, but it is reported that 25% filtered BOD removal can be obtained per pond for temperatures above 20°C.
- Oxidation ponds in parallel arrangement 99.99% fecal coliform reduction and can attain a 100% removal of helminths possible.

3. Cost Analysis of Oxidation Pond

- Oxidation Pond is reported to be one of the most efficient, high-performance, and low-cost wastewater treatment techniques adopted.
- The low-cost treatment processes WSP and UASB in terms of capital and annual O&M costs and land area requirements are compared to the mechanical aerated processes BAF and ASP in terms of costs.
- It has been found that the UASB system requires more capital and O&M costs than WSP. The capital and O&M costs for UASB and WSP systems were expressed by a first-order equation, which other researchers have also utilized. The capital cost for the investigated WSP is considered typical in India since it is similar to the other reports in India.
- Systems like ASP did not show much benefit in COD removal cost. So, finally, it was found that UASB could be economically the best option for India when considering all factors, including expenses and treatment efficiency.

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