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# Strategies for Wastewater Management: A Case of (a 1000 year old) Cuttack City[1]

**Rajnandan Patnaik**
Associate Professor, IMT Nagpur, India

***Abstract:***
*Wastewater management is essential for an old city like Cuttack as the city was created for a much lower population, where systematic town planning could never happen. Most of the storm water drains in Cuttack city has been transformed to sewage drains, polluting the environment and putting the population at risk. The risk becomes more pronounced when the sewage water is improperly discharged into the adjoining rivers, Mahanadi and its tributary Kathjodi. Further, town planning on wastewater management has always been leaning towards centralized wastewater treatment. This paper proposes different low-cost strategies that can be efficiently implemented for wastewater management, for Cuttack city. This research is a field work undertaken across three time frames, first in 2001, then in 2007 and now in 2011.*

***Key words**: Wastewater management, Sewage Treatment, Town Planning, Strategies, Cuttack*

## 1. Introduction

In comprehensive sewerage schemes, Sewage and Wastewater of a city are generally collected centrally and transported to mostly a single place, where the sewage and wastewater are treated before they are discharged into the flowing rivers or recycled. However, this form of centralized wastewater treatment remains capital intensive and with the ever increasing necessity of treatment of wastewater compounded with inability of the Government to provide adequate capital for centralized treatment plants, the option of low-cost decentralized wastewater treatment proposes its benefits, with low capital and operational costs, without compromising environmental sustainability (Ferguson et al, 1999).

This paper proposes the low-cost wastewater treatment for Cuttack city, to the extent possible identifying the areas where it may be taken immediately. Further, typical areas and the type of use will determine the extent of treatment and the technology adapted for the same. Moreover, Local community participation remains important for implementation and sustainability of the project. Overall, the decentralized approach of wastewater management needs necessarily be innovative, location specific, keeping the socio-cultural importance in view. Hence, it is important to understand the historical background of Cuttack that had given the city its character.

## 2. Background & Wastewater Parameters - Cuttack City

The city of Cuttack remains one of the important cities for the State of Orissa. The erstwhile capital, Cuttack remains the hub for cultural and economic development and houses important population of the state. The city of Cuttack, now popularly known as Silver City, is more than 1000 years old. The city was first planted around 989 AD by Raja Nrupa Keshari, but only in the 13$^{th}$ Century AD, the mighty Ganga ruler, Anangabhima III laid the foundation of the modern Cuttack by constructing the Barabati Fort and transferring his capital from the south. The last Hindu monarch of Orissa, Raja Mukunda Dev also ruled his vast kingdom from Cuttack. Cuttack remained the seat for administration during the reign of Mughals and Marathas. However, with the British invasion, the fort was destroyed and the stone blocks were used to construct a light house in Jobra, river embankments, Cantonment Road and various other British Structures. After independence from the British, the city remained the Capital of the State of Orissa. In the 1950s' the capital was shifted to Bhubaneswar, but till date such as the State High Court, Police Headquarters, State Public Service Commission, headquarters of major departments and many more. The city in the past has been the commercial capital and till date it remains a vibrant city.

[1] The field data is collected for this paper only to suggest strategic for wastewater improvements. The data should not be used as the only source for structural or process design purpose.

The City of Cuttack is surrounded by the river Mahanadi and its tributary Kathjodi on two sides. The topography of the city is flat and low lying (around Reduced Level - RL 22.0 m) and the level of rivers vary from around RL 20.0 m at low flows of 24 Cumecs (cubic meter per second) to RL 28.5 m at peak flood flows. In order to prevent inundation of the city by flood flows of the rivers, a bund with strong embankments surrounds the city that protects from the monsoon season, when the rivers flow several meters above the natural ground level of the city.

As per the Population Census, Government of India, the population of Cuttack City was 4,03,418 in 1991, grew to 5,35,139 in 2001, and rose to 6,06,007 in 2011. Basing on past growth, the population of Cuttack now is expected to be about 6,10,000 and the Town Planning Department project the population to cross 8 Lakhs by the year 2021.

Cuttack has a nonexistent sewerage system, where the open drainage system of the city is polluted by sewage, contaminated groundwater and garbage cast into the drains by local residents. The drainage system has inadequate capacity and during the monsoon (when discharge into the river is not possible), the drainage system overflows, floods the extensive low lying areas of the city causing dislocation and severe health risk to its population (mostly poor) and claims a heavy cost for clean-up and repair. Further, the environmental load from the drainage system to the rivers remains significant and is on the rise.

Cuttack Development Authority (CDA) has developed a residential area at Abhinab, Bidanasi, and Cuttack with independent water supply and sewerage disposal arrangements. It is expected that 1.2 Lakhs people from Cuttack town will migrate to Bidanasi by 2015 to settle in the area developed by CDA. Thus, it is inferred that about 7.4 Lakhs people will be residing in Cuttack other than Bidanasi area.

Extensive tubewell field set in a semi-confined aquifer remains the source of water supply in the city. At present the daily water supply is about 240 lpcd (litres per capacity per day), including 20% wastage. With this figure, the sewage to be generated will be about 130 MLD (million litres per day). Further, segregation of sewage generation denotes that about 97.5 MLD is generated from domestic households, about 26 MLD from Institutional and Commercial entities, and the rest 6.5 MLD from Industrial use.

At present there is a proposal to treat 37 MLD sewage at Matagajpur, the rest 93 MLD out of 130 MLD will remain untreated in the city. Sewage is channeled to septic tanks and so called "dry tanks"- that are emptied at intervals. Although, a sewage scheme was promulgated in 1965 and some sewers were constructed within the city, the work remains incomplete and the system remains dormant.

## 3. Pilot Area(S) For Wastewater Treatment

The sewage and wastewater of Cuttack city remains typical. One of the major objectives of this project is to provide low-cost sewage treatment, but such type of treatment ironically warrants more land area, which is costly and mostly unavailable in Cuttack. Further, during monsoon seasons, excess rainwater that again flows into the proposed areas outlined below, are mostly pumped to nearby drains by the municipality that in turn is left into the river. Moreover, various sewerage schemes and areas undertaken by one agency is not communicated properly to other giving the effect of "reinvention of wheel". This becomes clear when we realize that schemes undertaken by National River Conservation Directorate (NRCD), Cuttack Municipality, Orissa Water Supply and Sewerage Board (OWSSB), Archeological Survey of India (ASI) and some international social development donor agencies, are mostly efforts done in isolation. Thus, it becomes even more important that strategies need to be made keeping in view the earlier/proposed/future schemes for Cuttack city. This remains one of our major objective, i.e. to propose our strategy keeping other efforts in sync, to optimize the efforts and at the same time work towards a comprehensive sewage management strategy (Patnaik & Mohapatra, 2003).

The entire city of Cuttack will be segregated into different zones and the complete blueprint of the city will be prepared accordingly. After preliminary reconnaissance, we have earmarked some of the areas that can be undertaken for this project. Likewise, the entire city will be analyzed for other areas that can be undertaken for preparation of the complete blueprint. The relevant details of some of the proposed areas for Cuttack, along with the scope of low-cost treatment are outlined in the following:

### *3.1. Sewage of Ganga Mandir Tank*

The Ganga Mandir tank is located near the Gaurishankar Park on the backside of the City Hospital and the Old Jail. The tank is used by nearby residents and other population of nearby slums for bathing-washing and other toilet related activities. There are many sewage discharge points from various sources into the tank with sewage coming mostly from nearby households and slums. With an estimated population of about 20,000 of the area, the sewage generated is about 2.88 MLD. There is a possibility of land that can be acquired for treatment purpose with the land adjacent to the boundary wall of the Old Jail and the City Hospital. On-site treatment and subsequent beautification of the area can be proposed. OWSSB is preparing a scheme that includes some diversification of sewerage, but no treatment is proposed.

### *3.2. Sewage of Police Colony at Tulasipur*

The low lying area is located behind the Police Colony at Tulasipur with a local pond taking all the effluents of the nearby residential areas and the Police Institution. Further, the sewage from other neighboring areas also flow into this pond. A storm water drainage pump is also present in the area to contain the level of water in the monsoon seasons. With an estimated population of 25,000 of the area, the sewage generated is about 3.6 MLD. There don't seem to be any area constraint but the land available there is mostly of the Orissa Police Authorities. On-site treatment can be done there itself and the treated water can either be pumped or can be used for irrigation purpose. A storm water pumping station is present in the area that can be used to pump the treated water on to the riverbed for irrigation.

*3.3. Sewage of Gulguli Fall near Bidyadharpur*

The drain that falls into the river Mahanadi near Bidyadharpur is known as Drain No. 2. The area of the city to the east of National Highway and between Taladanda Canal and river Mahanadi is drained (including sewage) by this drain that runs from OMP Chhak to Bidyadharpur which discharges into the Mahanadi River through the Gulguli sluice. Most of the area covered by this drain belongs to the Central Rice Research Institute (CRRI), with the area upstream of CRRI premises is residential. After passing through the CRRI premises, the drain crosses the Mahanadi right embankment near Bidyadharpur and runs about 4 kms inside the flood plain to reach the river Mahanadi. Considering the catchment area of this main drain, the sewage contribution of the population is about 1 lakh. With this the sewage flow is calculated on the basis of 80% of water supply and 80% for interception, the sewage outfall at Gulguli falls is about 12 MLD. However, the report of Water and Power Consultancy Services (I) Ltd (WAPCOS) suggests the sewage flow at the fall to be about 6 MLD, calculated on the basis of Interception factor of 0.32. With this, we consider the outfall to be about 10 MLD. The sewage can be treated on-site and the treated water can be used for irrigation on the reclaimed land on the Mahanadi rived bed. The WAPCOS scheme that includes Gulguli Fall is taken up by NRCD, but its progress is extremely slow.

*3.4. Sewage of Pithapur Tank*

The Pithapur tank is located in the heart of Pithapur besides the road connecting Dolamundai and Choudhury Bazar, is surrounded by residential and commercial complexes on two sides. The tank is used by nearby residents and other population of nearby slums for bathing-washing and other toilet related activities. There are many sewage discharge points from various sources into the tank with sewage coming mostly from nearby households and slums. With an estimated population of about 10,000 of the area, the sewage generated is about 1.44 MLD. There is land constraint in the area. On-site treatment, pisciculture and retaining of the water body of the area can be proposed. Further, as a regular embankment of the tank exists, suitable plantations along the embankment can also be proposed.

*3.5. Sewage of Haripur Tank*

The Haripur tank is located in Haripur and is surrounded by residential and slums on all sides. The tank is used by nearby residents and other population of nearby slums for bathing and washing purpose and the tank also has religious significance with Lord Jagannath from his Dolamundai abode comes for boating during summer. However, there are many sewage discharge points from various sources into the tank with sewage coming mostly from nearby households and slums. With an estimated population of about 10,000 of the area, the sewage generated is about 1.44 MLD. There is land constraint in the area. On-site treatment, pisciculture and retaining of the water body of the area can be proposed. Further, with regular embankment, plantations along the embankment can be proposed.

*3.6. Sewage of Gadakhai (Killa Moat)*

The Killa (Cuttack Fort) remains a significant cornerstone in the history of Cuttack. It is identified as a heritage point by the Archeological Survey of India (ASI). The fort is located surrounded on all sides by a moat, popularly known as the Gadakhai. The fort holds residential areas, commercial and Government buildings, whose sewage is discharged into the Gadakhai. The Gadakhai, with no discharge points remains a stagnant water body with pollution rising from the sewage discharge from within the Killa and adjoining areas. On-site treatment, pisciculture and beautification of the water body of the area can be proposed. The existing water of the Gadakhai can be treated; recirculated and possible ground water link could be made so that the water remains pure for recreational activities such as boating etc. Although there is no land constraint in the area, but permission is perceived from the ASI to undertake the spot. Further, ASI has taken up the scheme to abate pollution of the moat and beautification of the area, but the progress by ASI seems tardy.

**4. Strategies for (Low-Cost) Sewage Treatment**

Intense efforts are being made in treating the sewage to make the effluent suitable for discharging into natural waters. Several processes of treatment that are available and actively followed (DFID, 1998; USEPA, 1988) include the following:

- Conventional activated sludge process
- Trickling filter method
- Oxidation / waste stabilization ponds,
- Aerated Lagoons
- Variations of anaerobic Treatment systems
- Up flow Anaerobic sludge blanket (UASB) Process
- Through service system of nature
  - Constructed wetland
  - Aquaculture
  - Land irrigation

In response to the primary objective of this project, that is to provide low-cost sanitation, Biotechnology promises the most as “Treatment through Service System of Nature”. Hence, we have outlined the above said low cost biotechnologies in the following. However, it is important to understand that the biotechnologies specified in the following have its own specific resource requirements, strengths-weaknesses, merits-demerits, operations and maintenance, cost requirements, availability and so on. Therefore, low-cost applicable biotechnologies are outlined in the following and the choice of the same will only be finalized after a detailed analysis of the area. Moreover, the possibility of usage of the above said technologies in part of in totality will also be analyzed.

**5. Low Cost Bio-Technologies Revisited**

Nature is the pure and divine and is said to be the cause of all material causes and effects, where as the living entity is the cause of various sufferings and enjoyments in this world. The mother earth and father wind have astonishing power to transform inorganic matter into, living tissues and support its growth with 'loved kinsman', water "friend", fire and the brother either. Clear understanding of relationship and interaction between nature and living entity is the knowledge, which establishes support system for preparation of activities from within the nature itself. The living organism and the plant life both explore the resources endowed in the nature for their sustenance. But due to inadequate and improper intellect, the human species destroy the natural ingredients for short term benefits. In the process they go outside the "Service system of Nature" and inflict services injuries bringing about catastrophe and self destruction. It is the time to check this suicidal process with firm conviction that for any problem created out of the process of exploration of resources there lies a solution in the service system of nature. We have only to endeavor to drive the right knowledge and technology to solve the problem (House, 1995).

In the kingdom of nature, the creation has been so designed that the waste of planet / living entity becomes food for another plant / living organism (Doll, 1996). It means that there exists a built-in-recycling process in nature, which would be searched out to meet the challenge of management of wastewater produced mainly by human action. The use and recycling of water resource is the right answer for a sustainable society. 'BIO- TECHNOLOGY and 'GENETIC ENGINEERING' have been recognized as major emerging science today (Reed et al, 1987).

Water is drawn from natural sources of supply purified, if necessary, and delivered to the community. The spent water, a majority of it is again returned to the receiving water on to land. The wastewater comprising of sewage and sullage needs purification before its recycling in order to reduce environmental hazards.

**6. Construct Wetland**

Wet lands provide pollutant-filtering systems and contribute significantly to ground water recharge. Because of the transitional position of landscape between terrestrial and aquatic ecosystems, some wet lands have been subjected to waste water discharge from both municipal and industrial services. Wetlands also receive agricultural and surface runoff, irrigation return flows, urban storm-water discharges, leakages and other sources of water pollution (Hammer, 1989).

Only few decades back the planned use of wetland for meeting wastewater treatment and other quality objectives have been studied and implemented. It is found evident that wetlands are able to provide a high level of wastewater treatment (House at al, 1993). Due to this factor, considerable interest has been developed in using constructed (or artificial) wetlands for wastewater treatment.

Wastewater treatment in waste stabilization pond (WSP) is done efficiently and economically. The types of WSP and their functions are given below:

WSP system comprises a single series of anaerobic facultative and maturation ponds or several such series in parallel. In essence, anaerobic and facultative ponds are designed for BOD removal and maturation ponds for pathogen removal although some bio-oxy demand (BOD) removal occurs in maturation and some pathogens removal in anaerobic and facultative ponds.

When a relatively weak wastewater (upto 150 mg/l) is to be treated prior to surface water discharge, only anaerobic and facultative ponds will be required and there is no need of any maturation ponds. These ponds are so efficient at removing BOD that their inclusions substantially reduce land requirements.

Anaerobic ponds are commonly 2.5M deep and it received high organic loading (usually > 100g BOD/m$^3$d equivalent to > 3000 kg / had for a depth of 3M) they may contain no dissolved oxygen and their primary function is BOD removal. These ponds work extremely well in warm climate and removes 60% BOD at 20$^0$ C. They contain 'Chlamydomonas' on the surface which functions much like open septic tanks and mainly function in removing BOD.

Facultative ponds are of two types: Primary facultative that receives raw sewage water and Secondary facultative ponds that receives settled waste water (i.e. the effluent of anaerobic ponds). They are designed on the basis of relatively low surface loading (i.e. 100-400kg BOD/ had) to permit the development of healthy algael growth as the BOD removal by the pond bacteria is mostly generated by photosynthesis (Sauter & Leonard, 1997).

As a result of photosynthetic activities of the pond algae, there is a dismal variation in the concentration of dissolved oxygen. After sunrise, the dissolved oxygen level gradually rises to a maximum in mid-afternoon, after which it falls to a minimum during the night. The position of oxypause similar changes, as does the PH since at peak algael activity carbonate and Bicarbonate ions react to provide more carbon dioxide for the algae, so leaving an excess of hydroxyl ions with the result that the PH can rise to above I which kills fecal bacteria. The wind has an important effect on the behavior of facultative ponds as it makes vertical mixing of pond liquid (House & Broome, 1990).

A series of 'Maturation ponds' (1 to 1.5M deep) received the effluent from a facultative pond, and the size and number of maturation ponds is governed mainly by the required bacteriological quality of the final effluent. Maturation ponds show less vertical biological and physiochemical satisfaction and well oxygenated throughout the day. Their algael population is thus much more diverse than that of facultative ponds with non-mobile general ending to be more common: algael diversity increases from pond to pond along series. Mainly it removes excreta pathogens. It is extremely efficient in a properly designed series of ponds.

Percentage of Bacterial removal in maturation ponds are given below:

| Sl. No. | Organism | % removal |
|---|---|---|
| 1. | Fecal coliforms | 99.97 |
| 2. | Fecal Streptococci | 9.99 |
| 3. | Clostridium perfringens | 99.40 |
| 4. | Campylobacters | 100 |
| 5. | Salmonella | 100 |
| 6. | Enteroviruses | 99.91 |
| 7. | Rota viruses | 99.63 |

*Table 1*

**7. Aquaculture for Waste Water Treatment**

Several variations of models of Aquaculture for treatment of domestic sewage have been proposed. Employing the biotic components such as bacteria, algae, duck weeds, microphyles and fish/shellfish is an aquatic ecosystem the principle of all models has primarily been dilution, oxidation and reduction of the suspended solids along with nutrient recovery in terms of biomes. Both autotrophic and heterotrophic, food chain operates in these systems, rendering the effluent nutrient deficient and less harmful to the environs to which they are discharged. 'Fish ponds' serve as facultative ponds for sewage treatment, also provides oxygen input from the photosynthesizing algae and macrophytes. The macrophytes also serve as nutrient pumps, reducing the entrophication effects that the sewage is likely to cause in the natural water (Helfrich, 1995). The different units of an Aquaculture Sewage Treatment Plant (ASTP) comprise of source, Duckweed culture complex, sewage-Fed Fishpond, marketing ponds and outlet.

The Duckweed's serve as nutrient pumps, reduce entrophication effects and provide oxygen from their photosynthesizing activity. Acqualic macrophytes used for treatment of domestic sewage were 'Azalea spp', 'Spirodela spp', 'Wolffia spp', and 'Lemna spp'. The approximate growth rates are

- Azolla spp - 160 g / $m^3$ / d
- Spirodela spp - 350 g/$m^3$ / d
- Wolffia spp - 280 g / $m^3$ / d
- Lemna spp - 275 g / $m^3$ / d

The harvested weeds could be used for feeding of grass carp (ctenopharyngodon ideal) in the marketing pond. Excess weeds can be used for composting.

Before stocking, ponds are dried up either by draining out the water through the exit pipelines or by pumping out. Sludge, which accumulates at the bottom of duckweed ponds and fishponds, are removed before filling with sewage effluents. The effluent requires stabilization for a few days and after chemical analysis of effluent and assessment of plankton populations, the fishes are stocked. Selections of species are done on the basis of commercial viability as well as proper management of available biological niches. Polyculture of crap (cutla, rohu, nurisal, and siluercarp, common carp and grass carp) is preferably over monoculture in sewage treatment system. The stacking density of fish 10,00/ha. The stocking rates of fish species in the fish ponds and markets ponds are as follows:

| Sl. | Species | In Fish Pond | In Marketing Pond |
|---|---|---|---|
| 1. | Catla *(Catla Catla)* | 25% | 10% |
| 2. | Rohu *(Labeo Rohita)* | 25% | 10% |
| 3. | Mrigal *(Cirrhinus Mrigala)* | 25% | 10% |
| 4. | Silver Carp *(Hypopthamichthys Molitrix)* | 15% | 10% |
| 5. | Grass Carp *(Ctenopharyngodon Idella)* | - | 50% |
| 6. | Common Carp *(Cyprinus Carpio)* | 10% | 10% |
| | TOTAL | 100% | 100% |

*Table 2*

Fishes are harvested after 8-12 months. When they attain marketable size. Harvesting is done by repeated netting and finally draining the water through the outlet.

After treatment through ASTP the BOD level is brought down to 18-22 mg/l and COD level to 32-52 mg/l. Total colliform comes to 0 to 44 MPN and Fecal Colifom is brought down to 0-23 MPN. This process completely removes salmonella and Faecal streptococci. The Aerobic heterotrophic bacteria is brought down from 79.27 to 8.4.

**8. Land Irrigation**

Optimum utilization of sewage in agriculture means the complete and judicious use of its three main components i.e. water, plant nutrients and organic matter on the farm in such a way that (a) the pathogenic infection is neither spread among the farm workers nor among the consumers of sewage farm products, (b) the ground water is not contaminated (c) there is maximum outer per unit volume of sewage (d) there is no detoriation of the soil properties (e) non of the three components is washed. The principle to be born in mind in irrigation is to irrigate only when it is required and only to the extent it is required by the crop (Qasim, 1985).

The elements to be considered in determining hydraulic loading are the quantity of effluent to be applied, precipitation, evaporation piration, perolation and run off. For ittigation systems, the amounts of effluent applied plus precipitation should equal. The evapotranspination plus an amount of percoltim. In most cases, surface run off from fields irrigated with sewage effluent is not allowed or must be controlled. The water balance then will be: Precipitation + waste water application = Evapotranspination + Percolatum. Sewage contains 26-70 mg/l of nitrogen (N), 9-30 mg/l of phosphate ($P_2 05$) and 12-40 mg/l or even more of potash (K200). The recommended dosages for N.P.K. for majority of field crop are in the ratio 5:3:2 or 3 respectively. Sewage is poor in phosphate. Excess potash is not significant but little excess of nitrogen effects crop growth and development. Land requirement is evaluated as: A = 3.65 Q/L , Where A = Field area in hectares Q = Flow rate in cum / day, L= Annual liquid loading in Cm / year (Patrick, 1976).

## 9. Conclusion

Wastewater management is essential for an old city like Cuttack where sewage drains pollute the environment and puts the population at risk with improper untreated discharge into the adjoining rivers, Mahanadi and its tributary Kathjodi. Further, town planning on wastewater management could not undertake centralized wastewater treatment, as capital and land requirement are too large. This paper solves this problem by different low-cost strategies that can be efficiently implemented for wastewater management, for Cuttack city. Comprehensive sewerage schemes collect sewage and wastewater and transport them to one location, which becomes expensive. Thus the option of low-cost decentralized wastewater treatment proposes the direct benefits of low capital and operational costs, thereby ensuring sustainability.

As this paper is a field work, it is easier to propose the decentralized low-cost wastewater treatment for Cuttack city after due identification of the areas where it can be taken up immediately, considering ground realities. Further, typical areas and the type of use determine the extent of treatment and the technology adapted for the same. Local community participation is deemed important for implementation and sustainability of the project, as their ownership will ensure sustainability. Overall, the decentralized approach of wastewater management seems in this case to be innovative, location specific, keeping the socio-cultural importance in view. This paper provides a practical solution (through its various strategies) to the sewage and wate problem of Cuttack city.

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