28th WEDC Conference Kolkata (Calcutta), India, 2002

SUSTAINABLE ENVIRONMENTAL SANITATION AND WATER SERVICES

Performance of deep oxidation ditch

Shah Ram Deep and Das Sunil Kumar, Nepal

BAGMATI RIVER IS the main river in the Kathmandu valley which makes a loop around the Pashupati Hill where the famous temple of Lord Pashupati Nath is located on its west bank. This river water has religious and spiritual values as Hindus consider the water of Bagmati river as a holy water or "JAL". The rivers of the Kathmandu valley are facing an acute water quality problem, which is not only threatening the river's aquatic ecology but also the cultural, religious and spiritual values of the millions of Hindu devotees. The direct discharge of untreated sewage from upstream areas of Gokarna, Boudha, Mitra Park etc. into Bagmati River polluted its flow damaging its sanctity. In order to provide healthy and clean water environment along the river and to safeguard the river water quality in the holy areas HMG/N, in 1996, constituted a High Powered Committee for Implementation and Monitoring of the Bagmati Area Sewerage Construction /Rehabilitation Project.

A Sewage Treatment Plant having capacity 16.42 MLD consisting of Carrousel type deep Oxidation Ditch based on extended aeration process was constructed on the bank of holy Bagmati river which provides primary and secondary treatments of sewage before the effluent is released into the holy river Bagmati. The critical trial run of the wastewater treatment plant was carried out in January 2002. During the trial period a lot of problems were faced to achieve the design parameters.

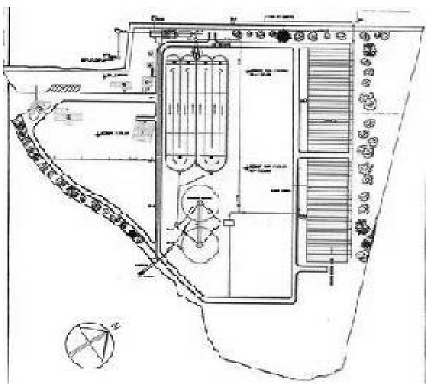

Figure 1. Layout plan

Design Parameters

Design parameters of the sewage treatment plant are presented in Table No. 1.

Experiences during initial trial runs

It was decided to put the treatment system into operation at a lower rate than the design capacity. One unit of the two nos. of oxidation ditch (OD-1) and both the secondary clarifiers (SC) supported with mechanical cleaning screen and grit removal mechanism were started on 22nd Jan, 2002. Inflow to the plant was maintained at 100 l/s with 100% re-circulation. Unfortunately, early next morning huge foaming occurred at OD-1 covering the major part of the ditch. However, the plant was continued to run partially at the same rate up-to 13th Feb, 2002. From 14th Feb. 2002, another unit of oxidation ditch (OD-II) was also put into operation maintaining a total flow of 100-150 lps and a sludge re-circulation @ 60-70%. However, an increase in flow up-to full capacity i.e. 200 lps again caused unusual foaming on 5th March 2002. Thus total flow was reduced to 100 lps with 100 % re-circulation. From March 6, 2002 and onwards the above phenomena was reduced greatly.

MLSS growth was observed very low i.e. below 1,000 mg/l at initial stage with D.O. concentration in the range of 4.5 to 6.5 mg/l. High D.O. content in the O.D. accelerated the process and might have caused some direct oxidation of organic matters which resulted into the significant reduction in B.O.D and C.O.D.

Table 1. Design parameters

Design flow	0.19m3/sec	% BOD removal efficiency	90 % min
Influent BOD	270 mg/l	Mean cell residence time	20 days
Suspended solid in Influent	216 mg/l	F/M Ratio	0.2
Influent COD	1150 mg/l	Hydraulic detention time	15.12 hr
Effluent BOD	25 mg/l	Mixed liquor suspended solid, (MLSS)	3500 – 4,000 mg/l
Suspended solid in Effluent	20 mg/l	Re-circulation Ratio	67 to 100 %
Effluent COD	250 mg/l	Oxygen Requirement	1.922 Kg/kg BOD

Figure 2. Oxidation ditch and secondary clarifier

Due to unavailability of fresh sludge cow-dung was added and mixed with water into the oxidation ditch to supplement biological activities in the oxidation ditch.

With the increase of temperature, MLSS concentration increased gradually in the OD. By the end of March, the MLSS in the OD were found to vary in the range of 1,530-1,925 mg/l, with D.O. concentration in the range 3.1 to 4.0 mg/l. It has been observed that microbes are generally tough against low temperatures. Many microbes appearing in activated sludge gave the fastest proliferation rate at the temperature above 20 ^{o} c. Oxygen consumption has also increased with rise in temperature. So, adequate range of temperature and pH is required for proper microbial activities to take place.

The composite sample taken between 15th April to 19th April, 2002 was analyzed and the result show that there was 71-80% reduction in COD, 81-84 % reduction in BOD.

It was analyzed that low MLSS value could be due to insufficient organic matter in the influent. Thus from the 1st week of May, flow was increased and maintained between 150-200 lps. A better housekeeping in OD and SC was attended with due care. A gradual increase in MLSS in OD and overall better performance was observed. Frequency of sludge rising in OD and SC was minimum up to 1st week of June. MLSS in OD was in the range of 4,000-5,000 mg/lit. However, during 2nd week of June and onwards rising of sludge in SC was considerable and the problem is still pertinent.

In the initial periods it was very difficult to find out competent and qualified local persons for operating the WWTP. Experts of contractor and project personnel have been involved at the commissioning stage. The final testing and commissioning of the plant was carried out in the presence of project's consultant from Switzerland.

For good operation, control and management of sewage Treatment Plant, this project always preferred to employ a specially qualified engineer whose undivided attention would be available. Shortage of qualified, trained and experienced personnel and ignorance on the part of the operator may lead to mal-operation of the treatment plant. In order to upgrade knowledge and skills in this field, on site training has been arranged to the technical persons recruited for the plant. Experienced trainers consist of sanitary engineer, mechanical engineer & chemist. Learning by doing coupled with exchange of experience form outside will indeed be a sound base for its success. During maintenance period, proper attention should be paid towards staff welfare, facilities and incentives, so that trained persons can be retained. However government and local municipal bodies have shown little interest to this vital issue.

Challenges faced during initial trial operation of the sewage treatment plant

Abnormal seasonal foaming in OD

In the very early stage of this newly constructed WWTP, excess foaming in OD was observed. More than 70 industries mainly wool dying and washing, carpet and garment industries exist in the catchments area of the project. Industrial wastewater is being discharged into sewer pipe without any pre-treatment. The industrial waste contains high concentration of detergent mixed up with fine textile fibers. Effluent reported supports their origin from textile washing. Under High agitation of surface aerators they caused foaming, which spilled over the OD. It was observed that high foaming generally occurred during cold temperatures and in the absence of sunlight. Foam got dispersed in sunlight. Reason for excess foaming in early stage could be analyzed due to little on going biological phenomena. A gradual higher biological activity with increase of MLSS in the plant, a condition for nitrification, inhibited the above phenomena. Use of frequent water spray was made to breakdown the foam; and better housekeeping was adopted to tackle these problems.

Rising of sludge in secondary clarifier

Rising of sludge and flotation of sludge mass with small gas bubbles have been observed frequently in the secondary clarifier, which could either be due to the anaerobic decomposition of the settled sludge at the bottom or due to de-nitrification process. As sufficient amount of oxygen is supplied to the mixed liquor in the OD, nitrification takes place in the plant and subsequently de-nitrification occurs. The flotation of the sludge impairs the quality of effluent due to presence of solids. However, after some improvement in the house keeping, cleaning of SC, adjustment of gap between Neoprene squeezer blades and floor of SC, some improvement was noticed. Some process control measures such as increasing the return sludge ratio and balancing sludge wasting rate were adopted; but still it has not been completely solved.

Figure 3. Foam in oxidation ditch

Combined sewer system

WWTP was designed to receive about 700 lps of storm water at the inlet chamber. The excess flow than the design capacity of plant is discharged through a bypass line. Open roadside drains feed most of the secondary sewer lines causing huge quantity of sand deposition in collection chamber. Poor joints in various old sewer pipelines may facilitate some ingress of sand quantity into the influent. Too much of silt and sand carried with the raw sewage which could not be separated out in the grit chamber pose problems of choking the sludge discharge line and deposition in different structure.

Poor solid waste management in upstream and human behavior

Most of the solid wastes thrown into a sewer line reach the sewage Treatment Plant through sewers. Solid waste dumped along roadsides gets into the intake through sewer lines/ open drains during storm. Also, solid dead bodies of animals and newly born babies are thrown into sewer line through manholes, which could be seen frequently in the collection chamber. These are however arrested in screens at the inlet point of STP and disposed off. Chicken feathers from roadside meat shops get access to the collection chamber, which pass through the screens and floats on the surface of oxidation ditch and secondary clarifiers creating nuisance.

Dissolved oxygen profile oxidation ditch

Dissolved Oxygen concentration values range from 0.2 to2.5mg/l in both ditches, and the value generally decreases from top to bottom. Oxidation Ditch stretch is 90 meter which makes the circuit too long. It has been observed that the gradient of dissolved oxygen concentration at different locations varies, which created aerobic and an aerobic conditions within the circuits. So both aerobic and anaerobic conditions have been obtained in the same circuit. By repeatedly switching between aerobic and anaerobic conditions, it facilitated nutrient removal.

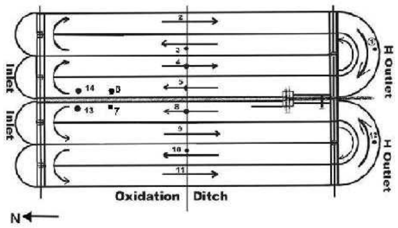

Figure 5. Location of DO and velocity measurement

Relationship between flow velocity and sludge deposition in oxidation ditch

- Aeration Equipment : 3 nos. of surface type vertical aerators
- Capacity of each unit = 5,187 cum.
- Total water depth = 3.5 m
- Water channel length of each unit = 350 m
- Channel width = 5 m

Flow velocity in Oxidation Ditch varies from 0 to 33cm/sec. The velocity to maintain the solids in suspension is 25 to 35 cm/sec: (Metcalf & Eddy, 1991). Some sludge deposition at the bottom is observed at sampling points No. 5 and 8 and low surface velocities are reported at station No. 6 & 7. This is due to surface turbulence at 6 & 7 and bottom turbulence at 5 & 8 due to aerator.

Performance of treatment plant

In order to evaluate performance of the plant, one full year operational data are required. However result of operation and average performance are available only for 2 seasons, which is summarized in Table no. 4 & 5.

Conclusion

- Commissioning of WWTP resulted into the clean water flow through the holy temples like Pashupati and Guheshwori. This was very much appreciated by the society. Nevertheless, it has positive impact on human health due to improved environment. As this type of plant does not generate offensive smell, people in the vicinity of the plant have no complaint at all.

Table 2. Dissolved oxygen profile in oxidation ditch

Measured Point		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Dissolved oxygen (mg/lit)													
Depth of Measurement	1.0m	1.8	-	1.8	1.2	11	-	-	1.0	1.0	1.0	-	1.0	1.0	1.8
	2.5m	0.6	-	1.1	1.9	0.3	-	-	0.2	1.5	1.0	-	0.2	1.1	2.5

Table 3. Velocity profile in oxidation ditch

Measured Point		1	2	3	4	5	6	7	8	9	10	11	12
		Velocity in cm/sec											
Depth of flow	0.5m	13	14	16	9	33	10	10	27	15	16	27	10
	1.5m	10	15	13	11	19	15	10	13	11	11	22	10
	2.5m	7	9	11	8	0 (Sludge depo)	8	8	0 (Sludge depo)	10	10	7	9

- Oxidation ditch achieved up to 92% BOD Removal, 85% COD removal, 73% S.S removal, 75% Ammonia-N removal and 60% Phosphorus removal.
- Some deposition has been observed in OD. So, mixing device like flow booster may be required to maintain solids in suspension in oxidation ditch.
- TSS load is almost twice the design value, which could have impact on the treatment process affecting the effluent quality standard. Some mechanism to control TSS concentration in collection chamber is required.
- In spite of all these problems, shock load performance of oxidation ditch is good on an average and it has capacity to absorb shock-load.
- Overall performance of an oxidation ditch plant depends on control of biomass and control over dissolved oxygen level, which need to be adjusted to meet changes in wastewater characteristics.

Lessons learnt

- It is quite necessary to collect and analyze the incoming parameters (chemical and biological) of raw sewage for at least one full year for designing any WWTP to suit local conditions.
- Since raw sewage is found to be mixed with storm water in rainy season; removal of sand, silt and debris in the pre-treatment stage should be duly considered during the design stage. Less attention on pre-treatment system merely for cost reduction can greatly reduce efficiency of the whole treatment system.
- Running and maintaining any WWTP involves money. Suitable modalities of public-private partnership should be envisaged during the inception stage.
- Disposal and burial of debris and dried sludge should be duly considered during the design stage.
- Such WWTP could be a very good model for undertaking various studies and R & D activities for the concerned academic and research institutions.
- Awareness programme should be conducted regularly for the common residents regarding minimization on generation and disposal of liquid and solid wastes.
- Due priority for human resources development working in wastewater treatment plant and proper attention towards staff welfare must be given.

References

Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal, reuse, 3rd edition, MC Graw Hill, New York, USA

Journal of the Institution of Public Health Engineers India, Volume 2000, (April-June), performance of oxidation ditch-A state of art.

EPA, Waste Water Technology Fact Sheet oxidation Ditches, September 2000, office of water Washington, DC

Hydraulic Calculation of Sewage Treatment Plant for Bagmati Area Sewerage Project, Kathmandu, Nepal, August 1999.

SHAH RAM DEEP, Senior Sanitary Engineer.
DAS SUNIL KUMAR, Civil Engineer.

Table 4. Result of operation, WWTP, Guheshwori, Kathmandu, Nepal (2002)

Parameter	Period I (Feb-April) 2002	Period II (May-Jun) 2002	Unit	Parameter	Period I (Feb-April) 2002	Period II (May-June) 2002	Unit
Waste water flow	8.64	12.96	10^3 m^3/d	**NH4-N inflow**	49.4	33.98	mg/lit
MLSS	1.268	2.674	Kg/m^3	**NH4-N effluent**	35.7	8.51	mg/lit
F/M ratio	0.41	0.27	Kg/Kg.d	**SS Inflow**	554	317	mg/lit
BOD_5 inflow	376	350	mg/lit	**SS effluent**	85	83	mg/lit
BOD_5 outflow	45	28	mg/lit	**Phosphorus Inflow**	7.56	5.86	mg/lit
COD inflow	882	794	mg/lit	**Phosphorus effluent**	4.0	2.31	mg/lit
COD effluent	181	115	mg/lit	**Energy Consumption**	2.63	1.96	Kwh/Kg BOD
TKN inflow	56.1	40	mg/lit	**Oxygenation capacity**	2.72	1.95	Kg O_2/Kg BOD
TKN effluent	47.4	12.5	mg/lit	**Temperature**	16.7	22	^0C

Table 5. Performance of WWTP, Guheshwori, Kathmandu, Nepal

Parameter	Period –I (Feb- Apr 2002)			Period –II (May-June 2002)		
	Inflow (mg/lit)	Effluent (mg/lit)	% Reduction	Inflow (mg/lit)	Effluent (mg/lit)	% Reduction
BOD_5	376	45	88.03	350	28	92
COD	882	181	79.47	794	115	85.51
SS	554	85	84.65	317	83	73.82
Ammonia-N	49.4	35.7	71.26	33.98	8.51	74.95
Phosphorus	7.56	4.40	41.79	5.86	2.31	60.58