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Attn Mr G T Westgate

FAIRWAYS OFFICE PARK - SEWAGE TREATMENT

A new office and industrial complex is planned for the Hillcrest area in Fischer Road. The site will require treatment facilities for the domestic sewage arising from the development. Industrial effluent will be tankered away. We have pleasure in hereby submitting our report on process selection and plant sizing for the domestic effluent.

Size of Development – Volume of Sewage

We have been informed that the plant should be designed for 232 kl/d of sewage

Selection of Treatment Process

The new EWS rules for small plants make it a requirement for plants to be operated by professionals for a minimum of 5 years. We prefer this and would like to undertake the service ourselves, as we would then be able to operate the plant as the design intended. This in turn makes the selection of an activated sludge process more attractive, as the plant should then get the degree of expertise and attention it requires to operate well. Activated sludge should also be significantly lower in cost than the other favoured alternative of a Rotating Biological Contactor (RBC) plant. We have therefore carried out a process sizing of an activated sludge process for your consideration.

In our experience sewages in KZN and the East Coast of RSA are deficient in alkalinity which limits nitrification to the detriment of final effluent quality. Provision will therefore be made for recycling of a portion of the clarifier overflow back to the septic tank to create a degree of denitrification in the septic tank, as well as providing the normal clarifier underflow return back to the head of the aeration tank. The effluent

recycle will conserve alkalinity and improve ammonia removal. The works layout should also allow for the addition of soda ash solution should this later prove necessary.

The process layout will therefore comprise a septic tank for primary treatment where the BOD will be partially reduced and the solids in the sewage will be settled out and digested. This will be followed by an activated sludge aeration tank for aerobic treatment and stabilization of the effluent and a secondary settling tank for settling out the activated sludge for recycle back to the aeration tank. The clarified effluent will be disinfected by chlorination or ultraviolet light (UV) and discharged. Provision will be made for effluent recycle back through the septic tank to assist denitrification and conservation of alkalinity. The same line will also be used to waste sludge back to the septic tank for stabilization before periodic tanker discharge.

1. Sewage Volume

As mentioned above, the plant will be sized for 232 kl/d of sewage.

2. Biological Load

This will be estimated in terms of Biochemical Oxygen Demand (BOD) rather than Chemical Oxygen Demand (COD) as most design criteria use BOD loadings.

Estimated BOD concentration - 400 mg/l

Estimated TKN concentration - 80 mg/l

BOD load = 92.8 kg/d

Ammonia load = 18.56 kg/d

3. Septic Tank

We have designed the septic tank sizing to allow it to cope with a degree of effluent recycling and to provide sufficient sludge storage for a reduced frequency of removal.

We recommend a two compartment septic tank of about 250 m³ capacity

We suggest nominal dimensions of 14.5 x 7 x 2.5 m with a primary compartment of 9 x 7 m and the secondary compartment of 5.5 x 7.5 m.

BOD in raw sewage = 92.8 kg/d

Assume a 30% reduction through the septic tank

Then BOD leaving septic tank = 65 kg/d

4. Biological Design Basis

The design criteria have been selected based on experience but are drawn from the Manual on the Design of Small Sewage Works published by the Water Institute of South Africa (WISA)

5. Aeration Tank

For the extended aeration activated sludge process we have selected a sludge age of 25 days with a sludge growth index of 0.55 and a maximum mixed liquor suspended solids (MLSS) concentration of 4 000 mg/l.

$$\text{Sludge mass} = 65 \times 0.55 \times 25 = 895 \text{ kg}$$

$$\text{Aeration volume} = 895/4.0 = 225 \text{ m}^3$$

$$\text{Sludge loading rate} = 65/895 = 0.073 \text{ kg BOD/ kg MLSS.d}$$

$$\text{Volumetric loading} = 65/225 = 0.29 \text{ kg BOD/ m}^3.\text{d}$$

The loadings are within recommended limits and therefore acceptable

$$\text{Aeration retention} = 225/232 = 0.97 \text{ days} = 23.3 \text{ hours}$$

Suggested aeration tank dimensions 12.0 x 6.0 x 3.2 m (SWD 3.5 m with freeboard)

6. Aerators

We recommend the provision of two slow speed turbine surface aerators in a rectangular aeration tank with compartments 6.0 m square and 3.2 m deep

Oxygen requirements – carbonaceous	$65 \times 1.64 \times 1.47$	$= 156.7 \text{ kg/d}$
Nitrogenous	18.56×4.57	$= 84.8 \text{ kg/d}$
Total		$= 241.5 \text{ kg/d}$
Per Hour		$= 10.1 \text{ kg/h}$
Per aerator per hour		$= 5.0 \text{ kg/h}$

Assume an alpha factor of 0.85 and a minimum DO level of 1.5 mg/l in the aeration tank.
Then clean water OC = $5.0/0.85 \times 8.4/6.9 = 7.2 \text{ kg/h}$

Assume oxygenation efficiency of 1.6 kg O₂/kWh into clean water

$$\text{Shaft power} = 7.2/1.6 = 4.5 \text{ kW}$$

Assume power factor of 0.85, a motor efficiency of 90% and a gearbox efficiency of 90%
then motor size = $4.5/.85 \times 0.9 \times 0.9 = 6.5 \text{ kW}$

Hence two 6.5 kW slow speed turbine aerators will be required.

7. Secondary Sedimentation Tank

With a peak factor of 3.5 and a maximum rise rate of 1.0 m/h the surface area of the clarifier will be 34 m^2 and the diameter 6.6 m. (or 6 m square)

Assuming a sludge return rate of 1:1 (recommended) the solids loading on the sedimentation tank will be $4.000 \times 9.7 \times 4.5 = 174 \text{ kg/h}$
Solids flux = $174/34 = 5.1 \text{ kg/m}^2 \cdot \text{h}$ (which is satisfactory)

We therefore recommend the provision of a conventional 6.6 m diameter sedimentation tank (or 6 m square) with 2.5 m sidewall depth, and a sloping floor to a central hopper.

8. Sludge return

The return activated sludge pump should be sized for nominal 1:1 (2.7 L/s) with duty plus standby pumps available.

9. Effluent Recycle

An effluent recycle pump (or gravity flow) should be provided to take effluent back to the septic tank at about 1.4 L/s. This should be coupled to the RAS line to waste sludge back to the septic tank when necessary.

10. Disinfection

Flow $232 \text{ m}^3/\text{d} = 9.67 \text{ m}^3/\text{h}$

Maximum chlorine dosage $10 \text{ mg/l} = 97$ (say) 100 g/h

Using 15% NaOCl @ 1.25 SG, volume = $100/(0.15 \times 1.25) = 533 \text{ mls/hour}$

A dosage pump of 550 ml/h capacity is recommended with turn down to less than 5%

Normal usage should be about 4 L/d. Use of the solution direct out of the drums is probably easiest.

A chlorine contact tank of about 10 m^3 capacity is recommended

*Alternatively, because of the problem in getting approval for chlorine disinfection, we can size a UV disinfection system which in turn avoids the problem of continuing to need to add chemicals, and the undesirable effects of chlorine residuals on sensitive environments.

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