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NOTE

Removal of Phosphorus and Recovery in Advanced HA-A/A-MCO Sludge Reduction Process

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In order to explore the method of improving phosphorous and nitrogen removal in sludge reduction technologies, an advanced process combining excess sludge reduction and phosphorous and nitrogen removal is developed, for short, HA-A/A-MCO process. The researching results show that when the amount of sidestream phosphorous removal sewage is 13 % of influent flow and the effluent phosphorous content of chemical phosphorous removal tank is 5 mg/L, effluent total phosphorus is less than 0.5 mg/L, which can fully meet the demand of First-degree-A Standards of GB18918-2002. Besides, increasing the phosphorous content from anaerobic release and controlling the effluent phosphorous content of chemical phosphorous removal tank being 5 mg/L can improve efficiency of chemicals, reduce medicament consumption and increase the phosphorous content of chemical sludge. And the phosphorous content of chemical sludge in HA-A/A-MCO system can be up to 18 %, which is equivalent with the content of phosphorous and can be recycled as production raw material of phosphorus fertilizer, replacing phosphate rock.

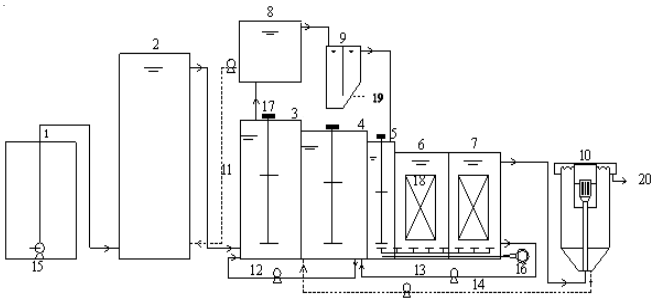
Key Words: Sludge reduction, Phosphorous anaerobic release, Phosphorous accumulating sewage, Phosphorus recovery.

Various types of sludge reduction technologies which were developed at home and abroad have many disadvantages and the most intractable problem is that the removal efficiency of nutriment appears low, especially phosphorous is much lower[1,2]. The phosphorus which is discharged along with municipal sewage not only wastes phosphorus resource, but prick up eutrophication. In this case, recovery and circular utilization of phosphorus in municipal sewage is of extreme importance. Especially, phosphorus can be recycled in the form of phosphate or fertilizer, rather than in the form of transferring phosphorus into sludge.

Aiming at the problem mentioned above, an advanced process combining excess sludge reduction and phosphorous removal is developed, for short, HA-A/A-MCO process (hydrolysis-acidogenosis-anaerobic/anoxic-multistep continuous oxic tank). The results show that this process is provided with good sludge reduction effect. This study is aimed to investigate the capability of phosphorous removal and recovery about HA-A/A-MCO process under the condition of low sludge yield.

HA-A/A-MCO is an advanced sludge reduction process which is developed by our research group, whose flow path is shown in Fig. 1.

It includes hydrolysis-acidification (HA) tank, anaerobic tank, anoxic tank, multistep continuous oxic tank, secondary sedimentation tank, sidestream sedimentation tank and chemical phosphorous removal tank. When the process operates steadily, influent flow is 20 L/h. Dissolved oxygen of each section of multistep continuous oxic tank is 0.5-1.5 mg/L, 0.5-1.5 mg/L and 1.0-1.5 mg/L. Return ratio of excess sludge, nitration liquor, denitration liquor and anaerobic phosphorus release sludge is



1. Influent Tank; 2. Hydrolysis Acidification Tank; 3. Anaerobic Tank; 4. Anoxic Tank; 5, 6, 7. No.1 Oxic Tank, No. 2 Oxic Tank and No.3 Oxic Tank of Multistep Continuous Oxic Tank, respectively; 8. Sidestream Sedimentation Tank; 9. Chemical Phosphorous Removal Tank; 10. Secondary Sedimentation Tank; 11. Phosphorus-release Sludge Return; 12. Denitration Liquor Return; 13. Nitration Liquor Return; 14. Excess Sludge Return; 15. Flow Control Pump; 16. Air Compressor; 17. Stirrer; 18. Filler; 19. High Phosphorus Sludge; 20. Effluent

Fig. 1 Flow sketch map of HA-A/A-MCO process

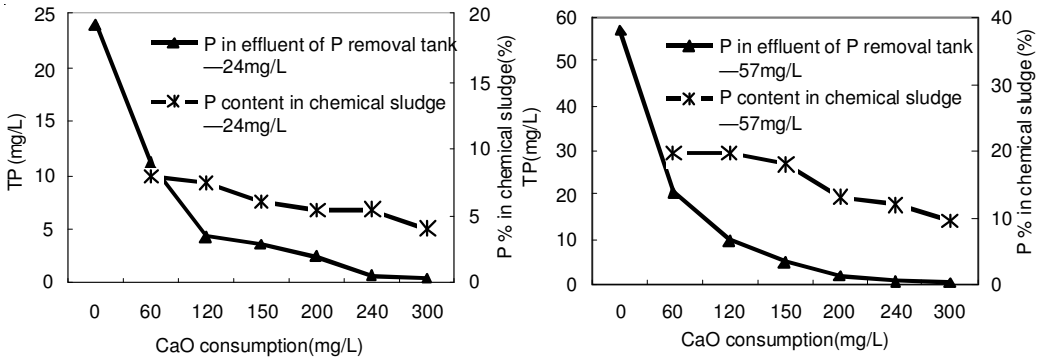


Fig. 2. Relation between dosage and phosphorus content in effluent of phosphorous removal tank and chemical sludge

40, 150, 100 and 2 %, respectively. Sludge retention time (SRT) of the system is 60 d, mixed liquor suspended solids (MLSS) is 5100-5800 mg/L and sludge load is 0.18-0.21 kg COD/kgMLSS.d

Experimental water quality: Experimental wastewater is campus sewage of Chongqing University by adding amylum, glucose, milk powder, NH_4Cl, KH_2PO_4. Characteristics of the influent are as follows: ρ(COD) = 316-407 mg/L; ρ(NH_3-N) = 30-40 mg/L; total nitrogen concentration ρ(TN) = 35-53 mg/L; ρ(TP) = 8-12 mg/L; pH = 7-8; temperature is 16-24 ºC.

Detection method: COD is analyzed by HACH-COD instrument, DO concentration is measured with an YSI oxygen meter, VFA is measured by distillation-titration method and other parameters were analyzed according to Ref. 3.

The proportion of anaerobic phosphorous accumulating supernatant entering chemical phosphorous removal tank is equal to 13 % of the influent. Add CaO into chemical phosphorous removal tank to remove phosphorus. The relation of phosphorus removal efficiency and medicament consumption with or without sludge returning into hydrolysis-acidification tank is showed in Table-1.

TABLE-1
RELATION OF PHOSPHORUS REMOVAL EFFICIENCY AND MEDICAMENT CONSUMPTION

Total phosphorus (mg/L)	2 % Sludge return, 57mg/L	No sludge return, 24 mg/L	Effluent TP (mg/L)
Medicament Consumption (mgCaO/L)	300	300	0.5
	200	200	2
	155	110	5
	135	90	8

The results in Table-1 show that medicament consumption of phosphorus removal can be reduced by controlling higher effluent phosphorus content of chemical phosphorus removal. Due to the sewage after phosphorus being removed needs to be returned into the system to participate in biochemical reaction process, effluent phosphorus content of chemical phosphorus removal can be controlled in 5 mg/L or so (not 0.5 mg/L), which induces that the consumption of CaO is just 50 % of that under the condition of controlling effluent phosphorus content in 0.5 mg/L.

Combining with the data in Table-1 and the analysis above, it is concluded that increasing anaerobic phosphorous release content and controlling the effluent phosphorous content of chemical phosphorous removal tank being 5 mg/L can improve efficiency of chemicals and reduce medicament consumption.

Fig. 2 reflects the translation of phosphorous accumulating sewages whose concentration is 57 and 24 mg/L respectively during the process of chemical phosphorous removal. The results show that when effluent phosphorous content of chemical phosphorous removal tank is controlled in 0.5 mg/L, phosphorous accumulating sewages whose concentration is 57 and 24 mg/L, respectively form chemical sludges whose phosphorous content is 9.4 and 4.1 %, respectively; When effluent phosphorous content of chemical phosphorous removal tank is controlled in 5 mg/L, phosphorous accumulating sewages whose concentration is 57 and 24 mg/L, respectively form chemical sludge whose phosphorous content is 18 and 7.5 %, respectively. It is obvious that increasing anaerobic phosphorous release content and controlling the effluent phosphorous content of chemical phosphorous removal tank being 5 mg/L can increase phosphorous content of chemical sludge.

In chemical phosphorous removal tank phosphorous accumulating sewages reacts with medicament (CaO) and forms $Ca_5(PO_4)_3OH$, $CaHPO_4$, $Ca_3(PO_4)_2$ and associated $CaCO_3$. Phosphorous content of every kind of compound containing phosphorus is 18.5 %, 22.8 %, 20 % respectively. When return ratio of anaerobic P-release sludge entering into hydrolysis-acidification tank is *ca.* 2 % of influent flow in HA-A/A-MCO system, phosphorous content of chemical sludge formed is up to 18 %, which is very close to that of compounds containing phosphorus. Thus, the sludge containing high phosphorus is worthy of recycle and can be recycled as production raw material of phosphorus fertilizer, replacing phosphate rock.

Conclusion

When the amount of sidestream phosphorous removal sewage is 13 % of influent flow and effluent phosphorous content of chemical phosphorous removal tank is 5 mg/L, effluent total phosphorus is less than 0.5 mg/L. Moreover, the phosphorous content of chemical sludge in HA-A/A-MCO system can be up to 18 %, which is equivalent with the content of phosphorous compound and can be recycled as production raw material of phosphorus fertilizer, replacing phosphate rock.

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