Water Pollution / Equipment for water pollution control (8)

Removal of phosphorous from waste water

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Japan Environmental Management Association for Industry
(JEMAI)

CONTENT

1. Mechanism of biological removal of phosphorous

1. 1 Outline

- In general biological treatment phosphorous is indispensable nutrients to synthesize bacterial cells.
- Generally the concentration of phosphorous in cell is 1～2% of dry cell weight.

  →The possible recovery amount of phosphorous by general biological treatment is about 1/100 of recovered BOD.
- The phosphorous removal from biologically treated waste water as a countermeasure against eutrophication mainly adopts coagulative separation by inorganic coagulant which can remove COD together.
- As recently the attitude of resource recovery has been enhanced the crystallization method such as HAP and MAP processes is mainly adopted.

- HAP method

  Phosphate ion is crystallized as hydroxyapatite（HAP）which is one of calcium phosphate compounds by adding calcium ion into raw water and adjusting pH.

$$10Ca^{2+} + 2OH^{-} + 6PO_4^{3-} \Leftrightarrow Ca_{10}(OH)_2(PO_4)_6$$

- MAP method

  Phosphate ion is crystallized as magnesium ammonium phosphate (MAP) by adding magnesium ion into raw water in the presence of ammonia and adjusting pH with alkali agent.

$$Mg^{2+} + NH_4^{+} + PO_4^{3-} + 6H_2O \Leftrightarrow MgNH_4PO_4 \cdot 6H_2O$$

- Biological phosphorus removal process is to utilize luxury phosphorus uptake phenomenon with activated sludge organisms.

  → Under certain environmental condition excess amount of phosphorous is incorporated into cells which amount is over than that is necessary to make cell of organism and is discharged outside the system as excess sludge which has high concentration of phosphorous.

  → This process has been developed mainly for sewage but stability of treatment is not enough.

1．2 Principal

・There are many unsolved parts about the detail metabolic mechanism of discharge and intake of phosphorous by activated sludge organisms.

According to the materials of Japan Sewage Works Association,

① Through anaerobic condition and subsequent aerobic condition, orthophosphoric acid absorbed by polyphosphate accumulating organisms is accumulated in cell as granule of polyphosphate.

② In anaerobic condition polyphosphate accumulated in cell is hydrolyzed and discharged into mixed liquor as orthophosphoric acid. On the other hand organic matters in mixed liquor are absorbed into cell. The higher concentration of organic matters in mixed liquor the higher discharge rate in general.

③ Organic matters absorbed into cell due to discharge of orthophosphoric acid in anaerobic condition is stored in cell as substrate of poly-β-hydroxybutyrate (PHB) etc.

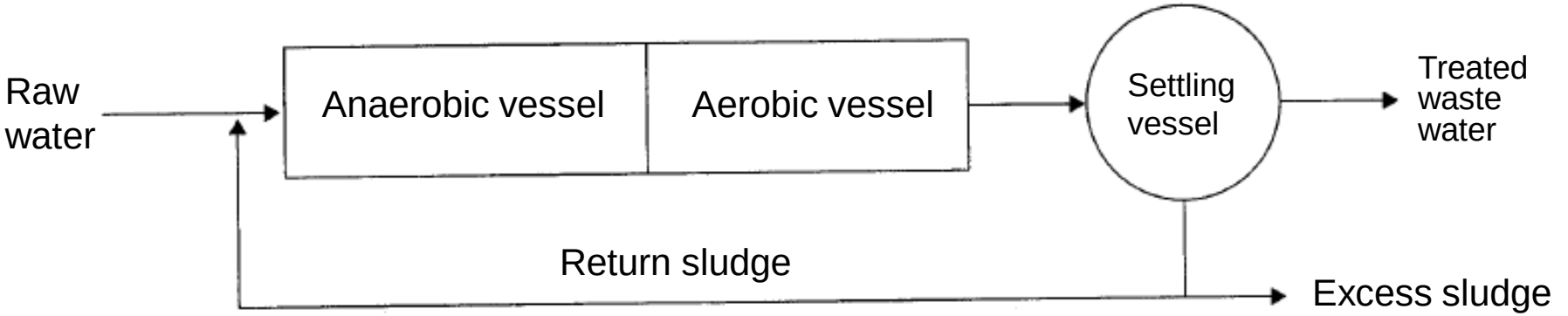
④ In aerobic condition these substrates in cell decrease because of oxidation and decomposition. By using this energy polyphosphate accumulating organisms absorbs more amount of orthophosphoric acid in mixed liquor than that discharged in anaerobic condition and resynthesizes them to polyphosphate.

⑤ By repeating ①～④ steps phosphorous content in activated sludge increases.

2. Organization of process

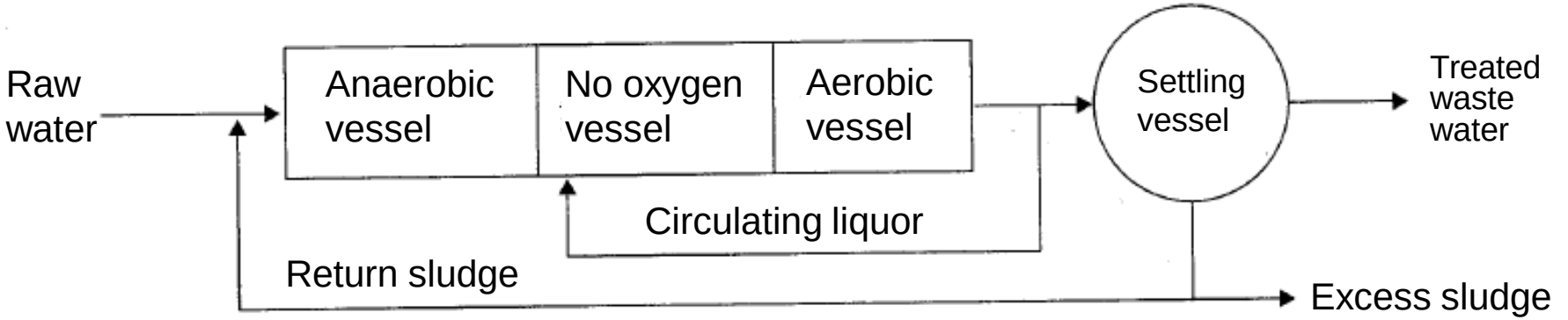
(a) Removal of phosphorus only:

Anaerobic·aerobic activated sludge method



(b) Simultaneous removal nitrogen and phosphorus:

Anaerobic·no-oxygen·aerobic method



- In anaerobic vessel phosphorous in sludge is discharged into mixed liquor in the presence of organic matters because of contact between raw water and return sludge. At latter aerobic vessel micro organism absorbs more amount of phosphorous than that discharged in anaerobic vessel and removes phosphorous as excess sludge.

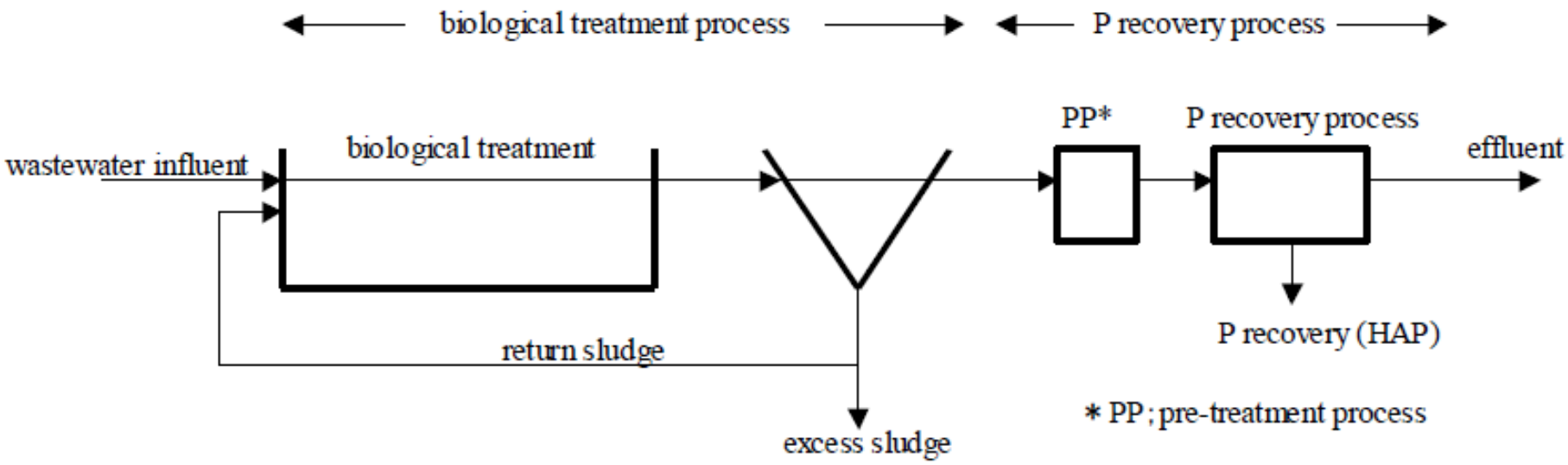
3. Basic operation condition

- In case of biological removal of phosphorous, phosphorous is removed by pulling phosphorous in excess sludge out of system.
- On the other hand the generation amount of excess sludge of activated sludge depends on the amount of SS and organic matters and it is not always connected with removal amount of phosphorous to keep some level of sludge concentration in mixed liquor.
- The content of phosphorous in sludge is easily affected by fluctuating load of organic matters and the problem that phosphorous is released into mixed liquor in anaerobic condition exists.
- Therefore if it is necessary to keep the concentration of phosphorous in discharge water under some level stably, in many cases it is necessary to use physicochemical removal process of phosphorous such as addition of coagulant together as complementary process with biological method.

4. Phosphorous recovery from waste water treatment

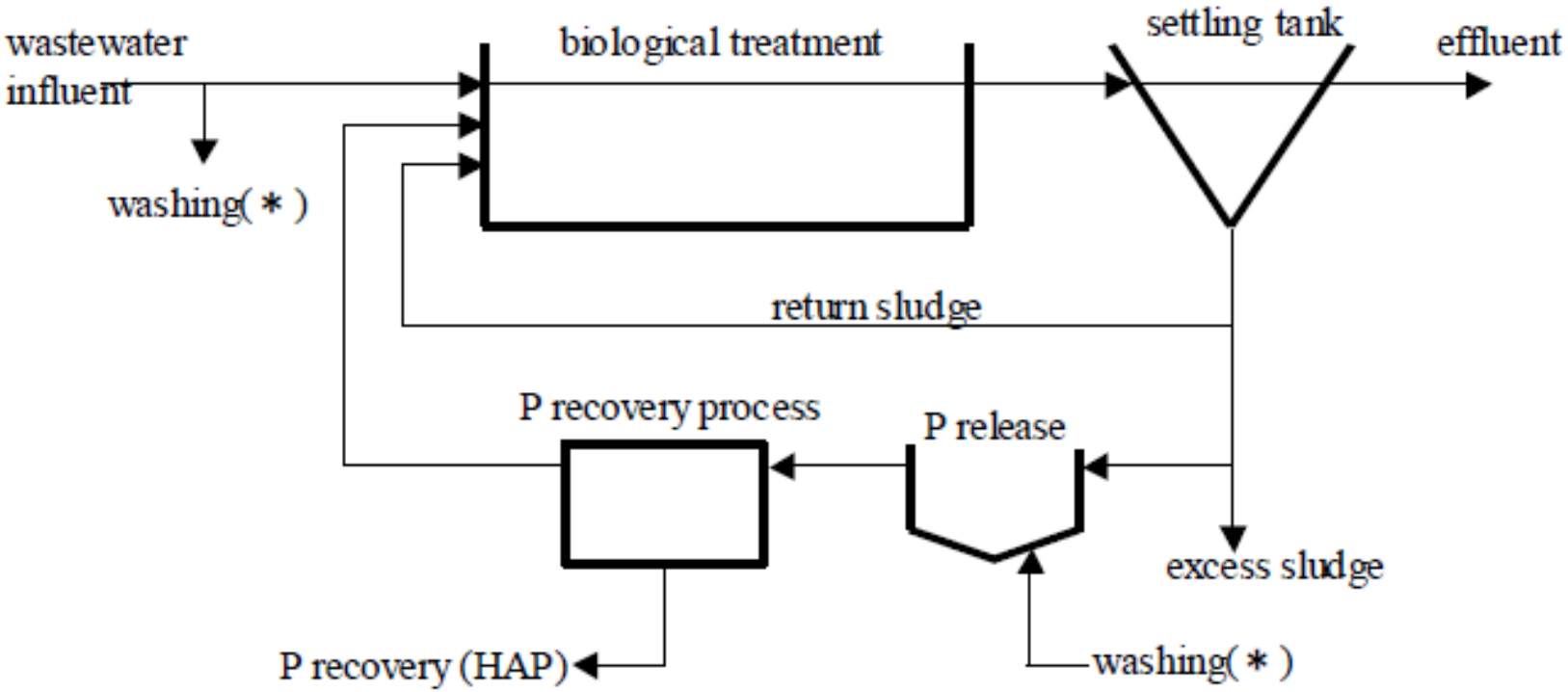
(a) Phosphorus recovery process of main stream type

- Pilot test
- Throughput 100㎥/d
  Phosphorus conc. in raw water 1.3～2mg/L
  Phosphorus conc. in treated water 0.2～0.37mg/L
  （average recovery ratio 78%）



(b) Phosphorus recovery process of side stream type (PhoStrip pocess)

- 1967　Levin et al（USA） Bio-chemical phosphorus recovery process
- Add dephosphorization vessel and lime coagulation vessel in activated sludge return line.
- Throughput　60㎥/d、
  Phosphorus conc. in raw water　T-P　4.5mg/L、PO_4-P　2.6mg/L
  Phosphorus conc. in bio-treated water T-P　0.37mg/L、PO_4-P　0.09mg/L



(c) Phosphorus recovery process of side stream type (Intermediate settling tank type)

- Pilot test

  Aerobic-anaerobic activated sludge process

  Anaerobic vessel 4㎥、Aerobic vessel 7㎥, Settling pond 7.5㎥

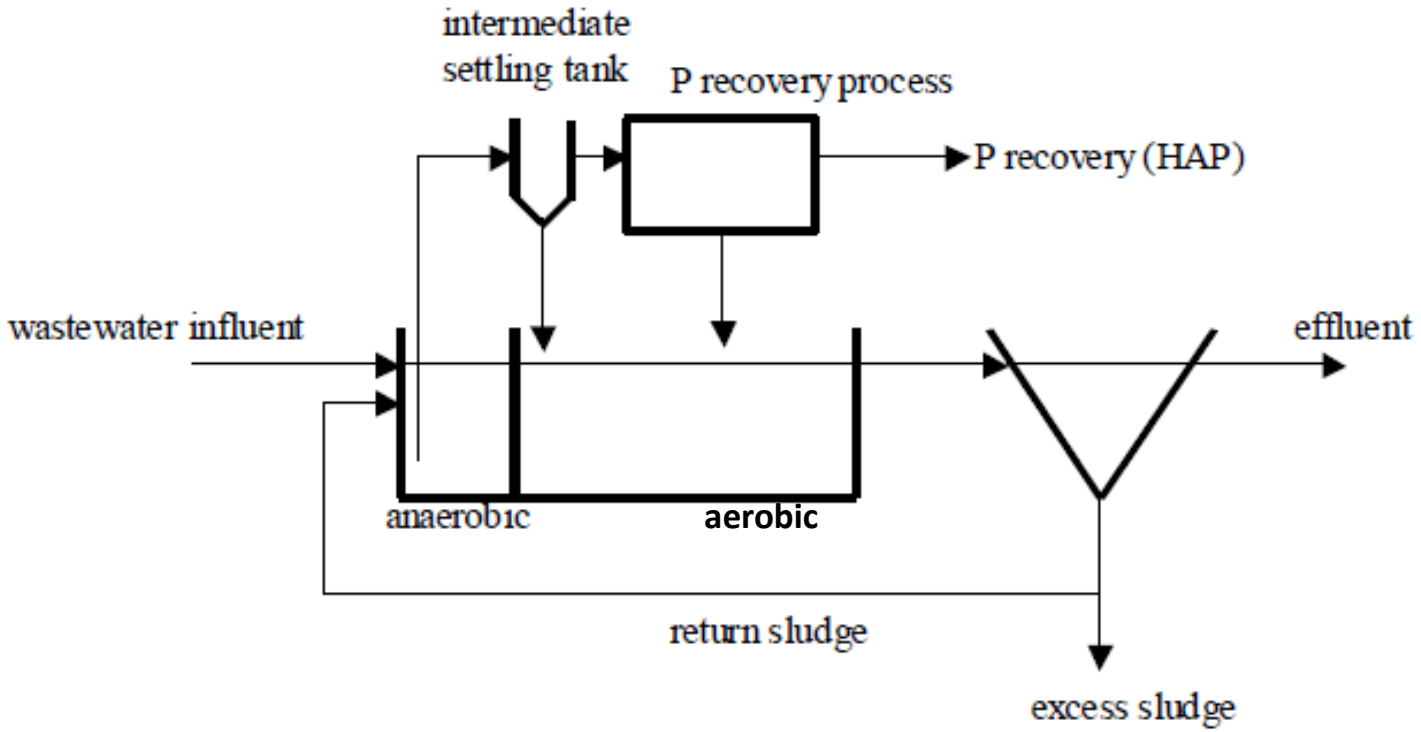
  Intermediate settling pond 1㎥, Fluid bed contact dephosphorization equipment 0.8㎥

- Throughput 50㎥/d, Phosphorus conc. in raw water T-P 6.7～7.7mg/L

  Throughput of Intermediate settling pond- contact dephosphorization equipment 7.1㎥/d, 15㎥/d

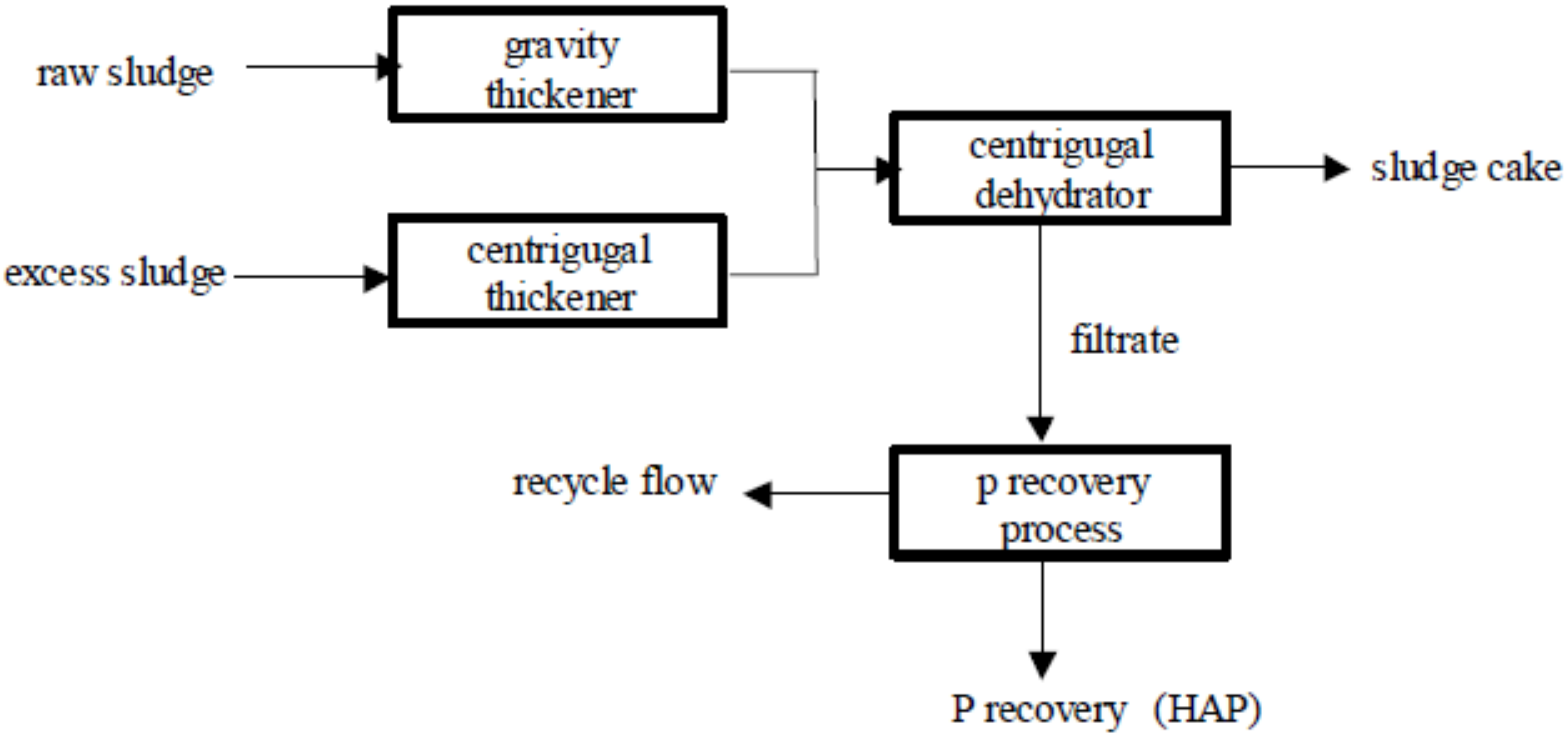
  Average phosphorous input 350g/d,

  Removed phosphorous by contact dephosphorization equipment 170g/d（about 1/2）



5. Phosphorous recovery from sludge treatment

(a) Phosphorus recovery process in the case of raw sludge dewatering



(b) Phosphorus recovery process in the case of anaerobically digested sludge dewatering

- Recovery of phosphorous from filtered water of anaerobic nitrification adopts MAP process because ammonium concentration in filtered water is very high such as several hundreds mg/L and several thousands mg/L.