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Integration of technologies for valorization of P and N for agronomical applications using industrial by produtcs (W2P Projet)

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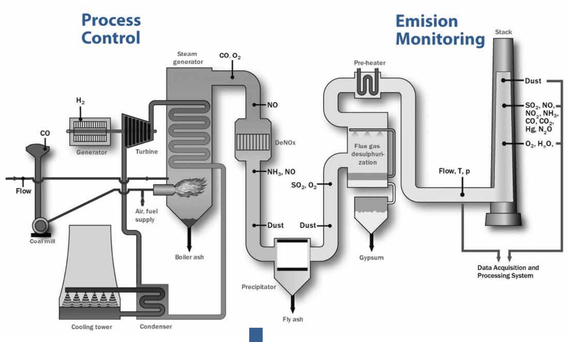
INTRODUCTION

The worries concerning the reduction of natural deposits of resources as it is the case of the P ores and the need to reduce the use of raw materials by promoting recycling have risen to a new paradigm of recovery of by products from wastes, and industrial and urban brines are presented as the most suitable candidates for the next decades. Then, **circular economy** has been postulated through the EU SPIRE program for the industry with a **resource recovery objective** .
The main efforts were traditionally addressed to seawater desalination brines where sodium chloride, potassium, magnesium and bromide salts could be recovered however other minor elements (Rb, Cs, P, In, Ge) have been identified as attractive. In the case of urban streams, as they typically are dilute wastes there is a lack of focus on selective removal, and the innovative recovery attempts have ben directed to nutrients (N, P). The P scarcity as a global challenge in the 21st century and the large use of fertilizers in developing countries and the demand of crops for bio-fuels are the principal reason for a increasing phosphate demand. Therefore, P recovery from wastewater has been transformed from an important environmental problem (e.g. eutrophication control) into a resources problem due to P ores shortage.

WASTE TO PRODUCT PROJECT (W2P) CONCEPT

Coal combustion plant



Flying Ashes (FA)

Synthesis

Powder Zeolite NaP1

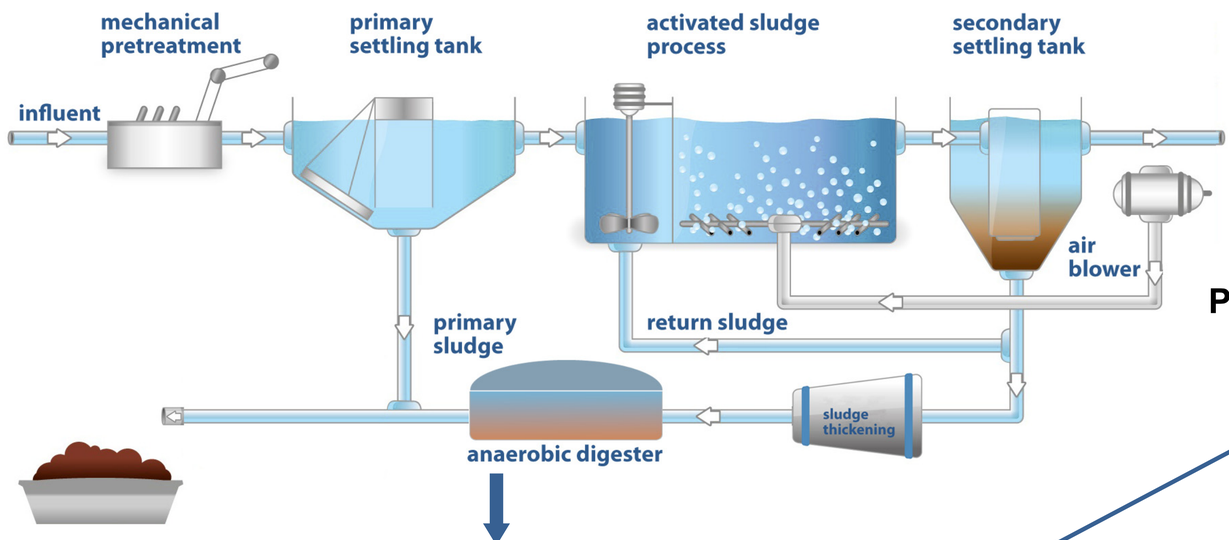
Modifications as:
-NaP1-Ca
-NaP1-Mg
-NaP1-K
-NaP1-Mn
-NaP1-Mg-K

Powder zeolites (PZ)

RO Brine: Ca^+, Na^+, K^+, Mg^{2+}

El Prat Sea water desalinization plant

Waste water treatment plant



1-2 g N/L / 0.1-0.5 P/L

Integration HYBRID processes (PZ-UF/PZ-NF)

By- Product:
Zeolite-P,N
Zeolite-Brushite/Hap
Zeolite-Struvite
FA- P,N
FA- Brushite/Hap

15-30 mg N/L / 3-10 mg P/L

Phosphate and ammonium concentration

Granular natural zeolites

1-5 g N/L

Liquid-liquid membrane contactor (LLMC)

NH_4NO_3, $(NH_4)_2SO_4$, $(NH_4)_2HPO_4$

Liquid fertilizer
Crystallization

$NH_4NO_3(s)$, $(NH_4)_2HPO_4(s)$

Hybrid polymeric/inorganic adsorbents

HFO-IX
FO36

FHFO-IX
FAS

GZ/HMO

1-2 g P/L

1-3 g N/L
0.5-1 g P/L

Crystallization / precipitation

Bipolar membrane electrodialysis(EDBM)

Hydroxyapatite (Hap)
$Mg_3(PO_4)_2$
$Ca_4Mg_5(PO4)_6$

NH_4Cl, NH_4NO_3 | H_3PO_4 Na_2HPO_4

W2P PROJECT OBJECTIVES

Solutions needed for valorization of diluted dissolved salts (e.g. P and N streams of urban and industrial WWTPs) need to implement selective separation, concentration and purification processes. To probe the concept of ***Waste 2 Product*** **(W2P) project** the following concepts will be evaluated:
W2P1. Integration of selective adsorption process of phosphate ions using hybrid inorganic sorbents prepared by adsorption of hydrated metal oxides (HMO) onto inorganic and organic ion exchangers for selective separation and concentration of P streams suitable to be valorized and P-Ca, P-Mg and P-Ca/Mg minerals.
W2P2: Integration of BPM-ED for selective separation, concentration and purification to produce concentrated ammonium and phosphate solutions for production of liquid fertilizers.
W2P3. Integration of non-selective sorbents as granular natural zeolites for NH_4^+ concentration step with Liquid-liquid membrane contactors (LLC) to produce pure NH_4NO_3 or $(NH_4)_2HPO_4$ using HNO_3 or H_3PO_4 as stripping solutions.
W2P4. Integration of a low cost non selective sorbent (e.g. modified powder synthetic zeolites with HMO or Ca^+, Mg^{2+}, Mn^{2+} ions, or rich Al, Fe and Ca flying ashes) as non selective multi-extraction and concentration of anionic and cationic nutrients (NH_4^+, K^+, HPO_4^{2-}, Mg^{2+}, NO_3^-) to produce as by-product a potentially slow-release fertilizers.
W2P5: Integration of NF and MD membranes for separation and concentration of multi-charged species (Ca^+, Mg^{2+} and SO_4^{2-}) from sea water desalination brines.

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