

# NEREUS Pilot Test Report

## Calcium Phosphate Route and Struvite Route

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European Regional Development Fund

from  
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## Executive Summary

Crystalactor (or Pellet Reactor), is a technology developed by Royal Haskoning (RHDHV) for recovery of Calcium Phosphate and Struvite from water or wastewater. It features a fluidized-bed reactor where chemical crystallization occurs with a compound formed with a target substance.

The objectives of the pilot were to confirm the applicability of the Crystalactor technology for recovery of Calcium Phosphate and Struvite from a SW WWTW sludge dewatering liquor, define the Phosphorous removal efficiency of the Crystalactor pilot plant, obtain realistic OPEX and CAPEX costs and determine if there is a financially viable business case for offsetting OPEX and CAPEX costs by selling recovered product as agricultural fertilizer to potential re-users/buyers.

The Calcium Phosphate trial was run for a total of 28 days and the Struvite trial was run for a total of 24 days. Multiple samples were taken from each trial and results from the analysis were used to calculate the range of removal efficiencies that could be obtained by modifying pH and by dosing Calcium Chloride for the Calcium Phosphate trial and Ammonium,  $\text{NH}_4$ , for the Struvite Trial.

For the Calcium Phosphate trial, when pH was increased, crystallization efficiencies increased ranging from 57% at pH 6.5 to 95% at pH 9.1. When an excess of Calcium Chloride was added, crystallisation efficiencies ranged from 67% to 84%, leading to a conclusion that Ca-excess is of minor influence on the crystallization efficiency.

For the Struvite trial, when pH was increased, crystallization efficiencies increased from 48% at pH 7.2 to 70% at pH 8.2. When an excess of Ammonium was added, crystallisation efficiencies ranged from 67% to 58% leading to the conclusion that Ammonium excess on the crystallization efficiency is of minor influence.

In summary, only the Calcium Phosphate trial proved effective at removing P from the sludge dewatering liquor.

Using the data contained within the report, a full size plant would produce 581 Tonnes of Calcium Phosphate per year or 511 Tonnes of Struvite per year. Based on a 25 year design life, the minimum price required for Calcium Phosphate is 551.6 Euros/ Tonne to break even vs Totex. For Stuvite, the minimum price required to break even is 627.20 Euros/ Tonne. Values for Capex and Opex are shown in Table 1. It can be concluded that there is no business case for a full scale plant on this basis.

Other potential benefits including reduced maintenance requirements on SW sites and the possibility of reducing Phosphorous to within permitted limits on some SW sites may improve the financial viability of a full scale plant, but these need to be compared against other Phosphorus removal technologies which is outside the scope of this study.

Table 1 - Break Even Prices For Recovered Product Vs Totex

| Year | Capex       | Opex      | Totex       | Cumulative Totex Costs | Cumulative Annual Calcium Phosphate Recovery (Tons) | Required Breakeven Price Per Tonne - Calcium Phosphate | Cumulative Annual Struvite Recovery (Tons) | Required Breakeven Price Per Ton - Struvite |
|------|-------------|-----------|-------------|------------------------|---|--|--|---|
| 1    | € 1,600,000 | € 256,500 | € 1,856,500 | € 1,856,500            | 581   | € 3,195.35   | 511  | € 3,633.07                                  |
| 2    | € 0         | € 256,500 | € 256,500   | € 2,113,000            | 1,162   | € 1,818.42   | 1,022                                      | € 2,067.51                                  |
| 3    | € 0         | € 256,500 | € 256,500   | € 2,369,500            | 1,743   | € 1,359.44   | 1,533                                      | € 1,545.66                                  |
| 4    | € 0         | € 256,500 | € 256,500   | € 2,626,000            | 2,324   | € 1,129.95   | 2,044                                      | € 1,284.74                                  |
| 5    | € 0         | € 256,500 | € 256,500   | € 2,882,500            | 2,905   | € 992.25   | 2,555                                      | € 1,128.18                                  |
| 6    | € 0         | € 256,500 | € 256,500   | € 3,139,000            | 3,486   | € 900.46   | 3,066                                      | € 1,023.81                                  |
| 7    | € 0         | € 256,500 | € 256,500   | € 3,395,500            | 4,067   | € 834.89   | 3,577                                      | € 949.26                                    |
| 8    | € 0         | € 256,500 | € 256,500   | € 3,652,000            | 4,648   | € 785.71   | 4,088                                      | € 893.35                                    |
| 9    | € 0         | € 256,500 | € 256,500   | € 3,908,500            | 5,229   | € 747.47   | 4,599                                      | € 849.86                                    |
| 10   | € 0         | € 256,500 | € 256,500   | € 4,165,000            | 5,810   | € 716.87   | 5,110                                      | € 815.07                                    |
| 11   | € 0         | € 256,500 | € 256,500   | € 4,421,500            | 6,391   | € 691.83   | 5,621                                      | € 786.60                                    |
| 12   | € 0         | € 256,500 | € 256,500   | € 4,678,000            | 6,972   | € 670.97   | 6,132                                      | € 762.88                                    |
| 13   | € 0         | € 256,500 | € 256,500   | € 4,934,500            | 7,553   | € 653.32   | 6,643                                      | € 742.81                                    |
| 14   | € 0         | € 256,500 | € 256,500   | € 5,191,000            | 8,134   | € 638.19   | 7,154                                      | € 725.61                                    |
| 15   | € 0         | € 256,500 | € 256,500   | € 5,447,500            | 8,715   | € 625.07   | 7,665                                      | € 710.70                                    |
| 16   | € 0         | € 256,500 | € 256,500   | € 5,704,000            | 9,296   | € 613.60   | 8,176                                      | € 697.65                                    |
| 17   | € 0         | € 256,500 | € 256,500   | € 5,960,500            | 9,877   | € 603.47   | 8,687                                      | € 686.14                                    |
| 18   | € 0         | € 256,500 | € 256,500   | € 6,217,000            | 10,458  | € 594.47   | 9,198                                      | € 675.91                                    |
| 19   | € 0         | € 256,500 | € 256,500   | € 6,473,500            | 11,039  | € 586.42   | 9,709                                      | € 666.75                                    |
| 20   | € 0         | € 256,500 | € 256,500   | € 6,730,000            | 11,620  | € 579.17   | 10,220                                     | € 658.51                                    |
| 21   | € 0         | € 256,500 | € 256,500   | € 6,986,500            | 12,201  | € 572.62   | 10,731                                     | € 651.06                                    |
| 22   | € 0         | € 256,500 | € 256,500   | € 7,243,000            | 12,782  | € 566.66   | 11,242                                     | € 644.28                                    |
| 23   | € 0         | € 256,500 | € 256,500   | € 7,499,500            | 13,363  | € 561.21   | 11,753                                     | € 638.09                                    |
| 24   | € 0         | € 256,500 | € 256,500   | € 7,756,000            | 13,944  | € 556.22   | 12,264                                     | € 632.42                                    |
| 25   | € 0         | € 256,500 | € 256,500   | € 8,012,500            | 14,525  | € 551.64   | 12,775                                     | € 627.20                                    |