PHORWater

Integral Management Model
for Phosphorus recovery
and reuse from Urban Wastewater

LIFE12 ENV/ES/000441

Economic and feasibility study

Project
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1. Overview

Given the scarcity of phosphorus, especially in Europe, the recovery and reuse of this resource from wastewater and sewage sludge has become a real growing concern. This recycle of phosphorus also involves significant environmental and operational improvements in wastewater treatment plants (WWTPs). In this regard, the need to remove the phosphorus from wastewater has increased throughout Europe as a result of the implementation of Directive 91/271/EEC (Directive related to the treatment of urban wastewater), especially when the effluent is discharged into an area classified as sensitive to eutrophication. Also actual Regulation (EC) no 2003/2003 of the European Parliament and of the council of 13 October 2003 relating to fertilisers is under revision to include the disposal of organic and waste-based fertilizers on agricultural soils and the use of recovered products from wastewater treatment plants as fertilizer.

2. Introduction

Although nowadays there are few implementations on industrial scale, different technologies that allow the recovery of phosphorus from wastewater have been developed. One of the most promising processes that offer greater possibilities is the recovery of phosphorus as magnesium ammonium phosphate hexahydrate, also known as struvite. Phosphorus recovery as struvite reduces the generation of sludge, and therefore the costs of chemical reagents needed for its management, as well as the land required for its disposal, and it also enables obtaining a product with a high value

as agricultural fertilizer. That is the reason why, today, the recovery of phosphorus from wastewater is a significant process for achieving the sustainable development.
However, this recovery of phosphorus requires efforts in both technical and economic fields (Pastor et al., 2008) ; according to the information available, there are no economic incentives in the market for the implementation of the appropriate technologies. In terms of profitability, it is not interesting for the fertilizer industry because the recovery of phosphorus as struvite is more expensive than the phosphate rock mining itself. Nevertheless, it should be taken into account that the recovery of phosphorus from wastewater provides significant environmental benefits such as preventing the area that receives the effluent from eutrophication, and increasing the availability of a non-renewable resource.
In conclusion, when the economic feasibility of projects with environmental impacts is analysed, it is really important not only to quantify the internal costs and benefits but also the environmental externalities associated. (Hernández et al., 2006). Indeed, conducting economic feasibility studies that consider these environmental impacts is a very complex task since most of them do not have a market value.
PHORWater project, framed within the LIFE+ funding with the contribution of the European Union, develops the first integral management model for WWTPs in order to enhance phosphorus removal and its recovery as struvite. In this sense, problems caused by uncontrolled struvite precipitation and eutrophication will be reduced and the obtained struvite shall be used as fertiliser. PHORWater works not only minimizing

management problems at WWTPs and environmental problems but also obtaining a valuable product from wastewater. With this aim, a cost-benefit analysis (CBA) on PHORWater project will be carried out. This methodology has been widely used and it is a useful decision-making tool. The CBA is based on the evidence that a project is economically feasible only if all its benefits are greater than costs. In accordance with this idea, the benefits of each alternative are compared to their costs using a common analytical methodology.

$$NB=B_T-C_T$$

Eq. 1.

Where the net profit (NB) is the difference between the total benefits (BT) and the total costs (CT). If the net profit (NB) is greater than zero, then the project is economically feasible, whereas if the NB is less than zero, the project is not feasible from the economic point of view. The best option is always the one that offers the higher net benefit.

3. Benefits of the recovery of phosphorus.

The total benefits from the recovery of phosphorus from wastewater are the result of adding the internal and the external benefits. The internal benefits are those directly related to the process of phosphorus recovering and reusing, and they can be quantified directly in monetary units since its value is determined by the market. On the other hand, the external benefits are the positive environmental and social outcomes of the project and they do not have a market value, thus its quantification requires complex economic valuation methods.

The total benefits (BT) from the implementation of the new technology will come by adding both internal benefits (IB) and external benefits (EB).

$$B_T = IB + EB$$

Eq. 2.

The first term comprises the revenues from the sale of the phosphorous recovered at the market value, as well as and the costs involved in the management of the sludge because it is produced in smaller quantities, and also those costs associated to a lower consumption of energy.

It has been proved that the product obtained can be used as fertilizer since it presents similar properties to those conventional ones (Taruya et al., 2000; Ahmed et al., 2006; Kataki et al., 2016; Ueno et al., 2001 among others). The estimations made by different authors point out that the market value of the struvite is between 188 and 763 €/t, (Molinos et al., 2011); whereas for the European Union, according to the MAP, it is about 245 €/t. For this study we have consider the value of the recovered material by multiplying the nutrient concentration in our product by their common market value (P: 1.7 €/kg, N: 1.1 €/kg, Mg: 0.3 €/kg, and Ca: 0.1 €/kg) (Egle, L., et al., 2016); giving a value of (302.05 €/t), Moreover, the savings in the operational costs obtained from the recovery of phosphorus in contrast to the conventional treatment for the removal of this nutrient is 2-3 € / kg P, as Dockhorn (2009) estimates and Berg et al., (2006) estimate the crystallization process costs for a 45,000 PE plant somewhere between €2.14 and €2.90 PE-1 per year.

Regarding to the external benefits, the recovery of phosphorus from wastewater develops positive externalities because it increases the availability of a non-renewable resource and produces significant environmental benefits on the area that receives the effluent. This is because in continental waters, such as lakes and rivers, when the concentration of phosphorus decreases, the growth of aquatic algae diminishes, thus the eutrophication problems decrease. Simultaneously, the recovery of phosphorus as struvite reduces the phosphorus non-point pollution by decreasing the concentration of this element in the sludge, and offers a product with stable known formulation with very low heavy metals concentration that allows controlling the amount of phosphorus spread wide on land while prevents from metal pollution, specially cadmium. Owing to its slow solubility in neutral and basic soils, struvite is an excellent slow-release fertiliser (Shu et al., 2006; Martí et al., 2010) that prevents plants from iron chlorosis and prevents nutrient run-off.

A way to estimate the environmental benefits of recovering phosphorus from wastewater is the estimation of the shadow price associated to this resource. Hence, the phosphorus that has not been removed during the wastewater treatment can be considered as an undesirable output because of the environmental consequences of its discharges, especially in areas sensitive to eutrophication, where it would have a serious negative impact on.

In this context, from the pioneering work developed by Färe et al., (1993), and other successive developments (Färe et al., 2001 and Färe et al., 2006), a valuation methodology of those that are known as undesirable outputs (outputs without market value) is provided. Therefore, it is considered the idea of obtaining a shadow price for those goods derived from human and productive activities (solid waste, wastewater, etc.) for which the market does not give any value but have significant environmental effects. These undesirable outputs can be considered as negative environmental externalities associated to a production process, in the sense that they can become in an environmental damage in case they were not managed correctly (Ha et al., 2008; Hernández et al., 2010; Molinos et al., 2010).

4. Objective.

It will be assessed the economic feasibility of the recovery of phosphorus from wastewater treatment plants throughout an innovative process (PHORWater), taking into account all internal and external impacts thereof, using an empiric formula to evaluate the economic value for the social and environmental associated benefits of the new process.
PHORWater project has been implemented at Calahorra WWTP, (La Rioja, Spain) with 23,000 m^3/d of wastewater treatment capacity. The water line consists of an activated sludge process operated for biological nitrogen and phosphorus removal (A2/O configuration) following preliminary treatment and primary sedimentation. Primary and secondary sludge are concentrated in gravity and dynamic rotary thickeners respectively and anaerobically stabilized. The sludge produced is dewatered and composted before its agricultural spreading. The effluent water from Calahorra WWTP ends up at the Cidacos

River.
This study will show the feasibility of the project, considering the benefits of its implementation not only on the economic profitability but also on quantifying the socio-environmental benefits.

5. Methodology for calculus of external impacts.

Wastewater treatment can be considered as a productive process, so if the phosphorus is not removed from wastewater, then its discharge causes a negative environmental impact on the receiving area. Therefore, phosphorus is an undesirable output derived from the wastewater treatment process, and the calculation of its shadow price provides quantification for the environmental benefit derived from the recovery of this nutrient. (Molinos et al., 2010).
The shadow price valuation methodology for undesirable outputs (Färe et al. 2006) is based on the concept of directional distance function. A distance function generalizes the concept of conventional production functions and measures the difference between the outputs produced in the process under study and the outputs of the more efficient process. It is considered that the most efficient process is the one that minimizes the consumption of inputs and the generations of undesirable outputs, and simultaneously maximizes the production of desirable outputs. Assuming that the production process uses a vector of inputs

$x=(x_1,...,x_N)\in R_+^N$ to produce a vector of desirable outputs $y=(y_1,...,y_M)\in R_+^M$ and a vector of undesirable outputs $b=(b_1,...,b_J)\in R_+^J$, and $g=(g_y,g_b)$ being the directional vector, and $g\neq 0$. The directional distance function is defined as:

$$D_0(x,y,b;g_{y,}g_b)=Max\{\beta:(y+\beta g_{y,}b-\beta g_b)\in P(x)\}$$

Eq. 3.

The distance function provides the maximum expansion of the desirable outputs and the reduction of undesirable outputs that is possible with a given technology $P(x)$.

The directional distance function parametrization is performed in a quadratic form (Chambers, 1998). Its application to a problem with $k=1,...,K$ units, operating in $t=1,...,T$, periods, and following the direction (1, 1), the directional quadratic distance function for the unit k in the period t is:

$$D_o^t(x_k^t,y_k^t,b_k^t;1,1)=\alpha+\sum_{n=1}^{N}\alpha_n x_{nk}^t+\sum_{m=1}^{M}\beta_m y_{mk}^t+\sum_{j=1}^{J}\gamma_j b_{jk}^t+\frac{1}{2}\sum_{n=1}^{N}\sum_{n'=1}^{N}\alpha_{nn'}x_{nk}^t x_{n'k}^t)$$
$$+\frac{1}{2}\sum_{m=1}^{M}\sum_{m'=1}^{M}\beta_{mm'}y_m y_{m'})+\frac{1}{2}\sum_{j=1}^{J}\sum_{j'=1}^{J}\gamma_{jj'}b_j b_{j'}+\sum_{n=1}^{N}\sum_{m=1}^{M}\delta_{nm}x_{nk}^t y_{mk}^t+\sum_{n=1}^{N}\sum_{j=1}^{J}\eta_{nj}x_{nk}^t b_{jk}^t$$
$$+\sum_{m=1}^{M}\sum_{j=1}^{J}\mu_{mj}y_{mk}^t b_{jk}^t$$

Eq.4.

The prices are represented by m, n and j. m represents the price of the desirable outputs, j, the price of the undesirable outputs and n represents the inputs.

In order to calculate the parameters ($\alpha_0, \alpha_n, \alpha_{nn,} \beta_m, \beta_{mm'}, \gamma_j, \gamma_{jj}, \delta_{nm}, \eta_{nj}, \mu_{mj}$) the sum of the distance between the production frontier and the individual observations for each period must be minimized:

$$Min = \sum_{t=1}^{T} \sum_{k=1}^{K} \left[(D_0^t(x_k^t, y_k^t, b_k^t; 1,1) - 0 \right]$$
$$s.t.:$$
$$(i) \quad D_0^t(x_k^t, y_k^t, b_k^t; 1,1) \geq 0, k = 1,...,K, t = 1,...,T,$$
$$(ii) \frac{\partial D_0^t(x_k^t, y_k^t, b_k^t; 1,1)}{\partial b_j} \geq 0, j = 1,...,J, k = 1,....,K, t = 1,...,T,$$
$$(iii) \frac{\partial D_0^t(x_k^t, y_k^t, b_k^t; 1,1)}{\partial y_m} \leq 0, m' = 1,...,M, k = 1,...,K, t = 1,...,T,$$
$$(iv) \frac{\partial D_0^t(x_k^t, y_k^t, b_k^t; 1,1)}{\partial x_n} \geq 0, n = 1,...,N,$$
$$(v) \sum_{m=1}^{M} \beta_m - \sum_{j=1}^{J} \gamma_j = -1; \sum_{m'=1}^{M} \beta_{mm'} - \sum_{j=1}^{J} \mu_{mj} = 0; m = 1,...,M;$$
$$\sum_{j'=1}^{J} \gamma_{jj'} - \sum_{m=1}^{M} \mu_{mj} = 0; j = 1,...,J; \sum_{m=1}^{M} \delta_{nm} - \sum_{j=1}^{J} \eta_{nj} = 0; n = 1,...,N;$$
$$(vi) \quad \alpha_{nn'} = \alpha_{n'n}; \beta_{mm'} = \beta_{m'm;} m \neq m', \gamma_{jj'} = \gamma_{j'j}, j \neq j'$$

Eq.5.

Then, in order to obtain the shadow prices of the undesirable outputs it is necessary to analyse the relationship between the maximum of the revenue function and the directional distance function. Given the vector of the price of the desirable outputs $p=(p_1,...,p_M)\in R_+^M$, and being $q=(q_1,...,q_J)\in R_+^J$ the vector of prices of undesirable outputs, the revenue function that considers the incomes generated by the undesirable outputs is defined as:

$$R(x,p,q) = Max_{y,b}\ \{py-qb:\ (y,b)\in P(x)\}$$

Eq.6.

The revenue function $R(x,p,q)$ provides the most feasible income that can be obtained from the inputs, x, when the price vector of the desirable outputs is p.
The assessment of the shadow prices of the undesirable outputs requires the assumption that the shadow price of one of the desirable outputs coincides with their market value. In other words, it is necessary to assign a reference price to the desirable output. Let y, being a desirable output whose market price is p, which is equal to its shadow price p_m, and let b being each one of the undesirable outputs whose shadow price is determined by the following expression:

$$q_j = -p_m \frac{\partial D_0(x,y,b;g)/\partial b_j}{\partial D_0(x,y,b;g)/\partial y_m}$$

Eq.7.

The mean value of the phosphorus shadow price is –160 €/kg, meaning that for every kg of phosphorus that is not dumped into the environment, the damage prevented, or the environmental benefit generated equals 160€. Once the shadow price associated to phosphorus removal has been estimated, the external benefit as €/year can be obtained directly by multiplying the shadow price by the daily average phosphorus recovery rate. This value is represented in equation 2.

6. Analysis of the economic feasibility of the project.

6.1. Investment costs

The investment costs of the project (Table 1) have risen to 136,202 euros, which have been distributed in: 82,132 euros for the design and the construction of the reactor; 35,938 euros for its implementation; and the rest went to the improvements of the implementation. The useful lifetime of the whole investment has been estimated in 15 years, considering an average inflation of 2 percent, with an estimation of the interest rate of 2 percent. The discount rate applied to the environmental benefits has been of 3 percent.

Table 1. Investment.

Improvement of the implementation	18,132.24 €
Reactor design & construction	82,131.85 €
Reactor implementation	35,938.12 €
TOTAL	**136,202.21 €**

6.2 Operational and maintenance costs

The operational and maintenance costs are focused on the consumption of two reagents: sodium hydroxide and magnesium chloride and the daily rate of the total maintenance costs (Table 2). The daily average cost of the reagents consumption has been 7.67 €/d, corresponding to 2,797.98 €/year; regarding the 1.19 kg/d of recovered phosphorus, the cost of these reagents represents 6.42 €/kg. From the operation experience, the observed daily maintenance rate was 4.64 €/d; therefore, regarding the amount of P recovered, the operating and maintenance costs represent 10.31€/kg of P recovered.

Table 2. Operation and maintenance.

INTERNAL COSTS				
	kg/d	Price (€/kg)	Cost (€/d)	Cost (€/y)
Magnesium chloride consumption	4.58	0.370	1.69	618.54
Sodium hydroxide consumption	9.63	0.620	5.97	2,179.44
Maintenance expenses			4.64	1,693.93
TOTAL			**12.31**	**4,491.91**

6.3 Internal benefits

According to the internal benefits derived from the implementation of the reactor, it has been verified an average reduction in sludge production of 3.34 t(d.m.)/month which is 109.61 kg(d.m.)/day. Assuming a disposal price of 37.11 €/t(d.m.) that includes composting of the sewage sludge and its agricultural spreading, savings due to the reduction in sludge production represent 4.07 euros per day (Table 3).

In annual terms, the production decreases in 40.117 t/year with savings estimated in 1,484.68 euros per year if we compare this with the situation previous to the implementation of the reactor.
In turn, the consumption of polyelectrolyte at the dewatering stage has been reduced by 1.87 kg/day, considering that its price is 2.34 €/kg, it represents 4.37 euros a day, always on average. On annual basis, the use of this reagent has been reduced in 682 kg, saving 1,595 euros. The new process has also allowed to reduce the energy consumption by 767.58 kWh/day in average, representing an average of 92.11 euros per day, with an estimated electric power rate of 0.12 €/kWh. In annual terms, the energy savings amount to 33,620 euros.
Moreover, if we bear in mind that Red Eléctrica de España, the one and only transmission agent and operator (TSO) of the Spanish electricity system, estimates at the "Spanish Electricity System 2015 Report" an average of CO2 emissions from the electricity sector of 0.289 tCO_2/MWh; the energy saving of 280.168 kWh would reduce emissions to 81.04 tCO_2 per year.

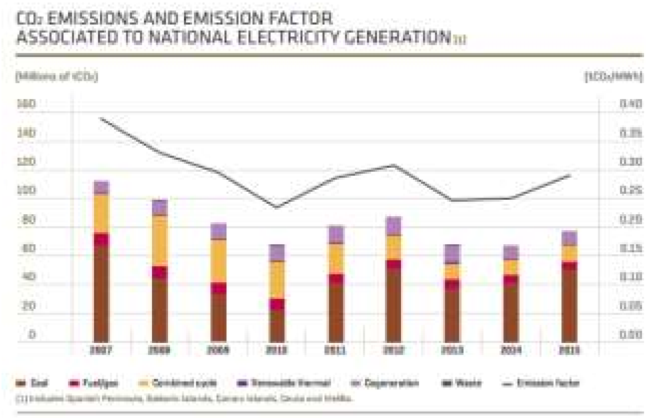

Fig.1. CO_2 emissions and emission factor associated to Spanish electricity generation

In addition, the total value of the internal benefits amounts to 100.55 euros a day (36,700 per year) against the costs of 12.31 euros per day (4,492 per year).

Table 3. Internal benefit.

INTERNAL BENEFIT			
	Before process implementation	After process implementation	Savings (€/d)
Sludge production (t(d.m.)/month)	70.33	66.98	4.07
Daily polyelectrolyte consumption (kg/d)	19.56	17.70	4.37
Energy consumption (kWh/d)	3,257.97	2,490.39	92.11
TOTAL			**100.55**

It has been considered that the recovery process was stable from June 2016 onwards; the production of struvite during this period was 9.46 kg/day on average, representing 3,453.62 kg annually. Using a reference price of 302 €/t it becomes in 1,043 € per year. The amount of phosphorus recovered was 1.19 kg/day on average, being valued in 2.39 €/kg.

6.4. External benefits

The removal of phosphorus in the wastewater treatment processes also produces significant positive impacts, especially environmental ones. Clearly, if this phosphorus is not recovered, it would end up being discharged into the environment driving to a significant damage. Using the methodology described above based on the calculation of the shadow price, it is obtained that the cost avoided, or the environmental benefit, is 160 euros per kg of phosphorus. Although this value is shown higher than the existing references in the literature, this value is entirely consistent as it was proved by the sensitivity analysis previously mentioned.

Taking into account that the estimated amount of the phosphorus recovered has been 436 kg per year (1.19 kg/day), the monetary value of the environmental benefits generated would result from multiplying this number by the shadow price obtained, reaching a value of 69,743 €/y. Furthermore, despite the difficulties of the quantification of the environmental benefits, associated with limited information, these costs give an idea of the magnitude of the cost of no-action and should be identify and quantify to avoid them being ignored.

Also, this greater recovery of phosphorus significantly reduces the risk of uncontrolled precipitation of struvite in the facility itself, avoiding expenses related to the repair and replacement of the equipment. This reduction of the risk is shown along the period of the implementation of the reactor.

The information about the costs and the benefits described above must be designed for a useful lifespan of 15 years for construction engineering. Therefore, the annual amortization gets a value of 9,080 euros with a constant amortization criterion. The operational and maintenance costs are estimated to increase each year with inflation, which is considered, on average, 2 percent. Referring to the value of the internal benefits in terms of savings in the production of sludge, and the consumption of reagents and energy, it has been estimated that they will rise each year accordingly to the inflation. The same approach has been applied to the sale of the struvite at the estimated market price.

Given these criteria, and not including the external benefits at this point, an analysis of the economic feasibility of the project has been carried out. Table 4 contains the Internal Costs that include the operating and maintenance costs (consumption of sodium hydroxide and magnesium chloride and maintenance expenses) with a constant depreciation for a useful lifecycle of 15 years. It has been considered that the operating and maintenance costs increase on average a 2 percent annually.

Table 4. Internal costs (€).

Years	Operating and Maintenance Costs	Amortization	Total Costs
1	4492	9080	13572
2	4582	9080	13662
3	4673	9080	13754
4	4767	9080	13847
5	4862	9080	13942
6	4959	9080	14040
7	5059	9080	14139
8	5160	9080	14240
9	5263	9080	14343
10	5368	9080	14448

11	5476	9080	14556
12	5585	9080	14665
13	5697	9080	14777
14	5811	9080	14891
15	5927	9080	15007
TOTAL		**136202**	

In regard to the Internal Benefits, which are shown in Table 5, it has been considered the income expected from the sale of the struvite, as well as the saving expected from the production of sludge, the reagent consumption, and especially the energy consumption. In all situations, it has been assumed an increase in the value of cost similar to the internal benefits.

Table 5. Internal benefits (€).

Years	Savings in the production of sludge	Savings in the consumption of polyelectrolyte	Sale of struvite	Savings in the consumption of energy	Total Internal Benefits
1	1485	1595	1043	33620	37743
2	1514	1627	1064	34293	38498
3	1545	1659	1085	34978	39268
4	1576	1692	1107	35678	40053
5	1607	1726	1129	36392	40854
6	1639	1761	1152	37119	41671
7	1672	1796	1175	37862	42505
8	1705	1832	1198	38619	43355
9	1740	1869	1222	39391	44222
10	1774	1906	1247	40179	45106
11	1810	1944	1272	40983	46008
12	1846	1983	1297	41802	46928
13	1883	2023	1323	42639	47867
14	1921	2063	1349	43491	48824
15	1959	2104	1376	44361	49801

Table 6 compares the values of the internal costs and benefits obtained for each one of the years of the useful lifetime of the project. The economic sustainability of the project is confirmed due to the positive annual net benefit throughout the entire period. This is a robust result that is not connected to the initial assumptions adopted. By calculating the Present Value of the annual net worth it has been reached a figure of 316,788 euros, which represents a profit over 200 percent of the initial investment; not taking into account the external environmental benefits generated by the project.

Table 6. Internal Net Benefits (€).

Years	Total Internal Benefit	Total Internal Cost	Net Benefit	The Present Value of the Net Benefit
1	37743	13572	24171	24171
2	38498	13662	24836	23697
3	39268	13754	25514	23232
4	40053	13847	26206	22777
5	40854	13942	26912	22330
6	41671	14040	27632	21892
7	42505	14139	28366	21463
8	43355	14240	29115	21042
9	44222	14343	29879	20630
10	45106	14448	30658	20225
11	46008	14556	31453	19828
12	46928	14665	32263	19440
13	47867	14777	33090	19058
14	48824	14891	33933	18685
15	49801	15007	34794	18318
TOTAL				**316788**

The assessment of the environmental benefits associated to the recovery of phosphorus has been carried out by a methodology based on the calculation of the shadow price. The value obtained for the first year of the project has been projected for the next 15 years of the lifetime of the reactor. Subsequently, it has been calculated the present value of the benefits achieved for each year with a discount rate of 3 percent.

As presented in Table 7, the monetary value of the environmental benefits generated is 857,568 euros. In addition, we should also consider the decrease of CO_2 emissions resulting from the reduction of the energy consumption. According to the above calculation, the reduction for the entire lifecycle is estimated at 1,215.6 tCO_2.

Table 7. Environmental Benefits (€).

Years	Environmental Benefit	The Present Value of the Environmental Benefit
1	69743	69743
2	71138	67712
3	72561	65740
4	74012	63825
5	75492	61966
6	77002	60161
7	78542	58409
8	80113	56708
9	81715	55056
10	83350	53452
11	85017	51896
12	86717	50384
13	88451	48916
14	90220	47492
15	92025	46108
TOTAL		**857568**

The overall feasibility of the project is given by the addition of the Internal Net Benefit and the Environmental Benefits, always in the present value. The Net Present Value (NPV) considers the initial investment at the earliest stage of the lifecycle; it considers that operating costs and internal and external benefits accrue during the lifespan. The final value amounts to 1,174,356 euros, representing a profit rate on the initial investment of 862 percent, it means that for the 15 years of useful lifetime, it is feasible to recover over 8.5 times the initial investment. The relevance of the results fully guarantees the economic and environmental feasibility of the technological proposal made.

After establishing the overall feasibility of the project, we want to know how long would the recovery of the initial investment take. Following the above criteria and not considering the environmental externalities, has been taken as a reference a period of 5 years for the full recovery of the investment and generation of a positive net profit. Detailed information is contained in the following tables 8, 9 and 10.

Table 8. Internal costs (€).

Years	Operating and Maintenance Costs	Amortization	Total Costs
1	4492	27240	31732
2	4582	27240	31822
3	4673	27240	31914
4	4767	27240	32007
5	4862	27240	32103
TOTAL		**136202**	

Table 9. Internal benefit (€).

Years	Savings in the production of sludge	Savings in the consumption of polyelectrolyte	Sale of struvite	Savings in the consumption of energy	Total Internal Benefits
1	1485	1595	1043	33620	37743
2	1514	1627	1064	34293	38498
3	1545	1659	1085	34978	39268
4	1576	1692	1107	35678	40053
5	1607	1726	1129	36392	40854

Table 10. Net Benefit (€).

Years	Total Internal Benefit	Total Internal Cost	Net Benefit	The Present Value of the Net Benefit
1	37743	31732	6010	6010
2	38498	31822	6675	5893
3	39268	31914	7354	5777
4	40053	32007	8046	5664
5	40854	32103	8751	5553
TOTAL				**28897**

As can be observed, the Net Present Value for 5 years after the beginning of the project is 28,897 euros. According to the criteria previously established and having made the corresponding sensitivity analysis, it has been estimated that from the fifth year the investment will be fully recovered.

7. Conclusion.

Phosphorus is an essential and a non-renewable resource that can be recovered from the wastewater, thereby contributing to the sustainable development. In addition, the recycling of these waste streams generates significant environmental and operating benefits in the WWTPs.

Although it is clear that the recovery of this nutrient is important, it is necessary to be aware of the significant efforts required in both technical and economic levels. We should keep in mind that the selling price of the phosphate rocks is lower than the price of the phosphorus recovered in the short term, which means that there are no economic external incentives for the implementation of the technology for the recovery of phosphorus in the wastewater field.

As a consequence, betting on a new technology for the recovery of phosphorus and demonstrating the economic and environmental sustainability becomes a challenge. In this case, a methodology to assess the overall feasibility of the process of recovering the phosphorus contained in wastewater considering not only internal but also external impact is applied.

In this sense, when the process of recovering the phosphorus contained in wastewater is analysed considering only internal costs and benefits, the results show that such projects are often not feasible in economic terms. However, in the present case, it has been proved a complete economic feasibility together with an extremely short return on investment (ROI) (only 5 years). These results have been obtained without considering the environmental benefits thereof.

In short, we can say that unlike what it happens usually with different technological alternatives for recovering the phosphorus, the present project shows that there exists an economic feasibility even without taking into account the high environmental benefits associated. In terms of the overall feasibility of the project, it is expected to get a benefit of 8.6 times the initial investment.

Strategy for struvite market development should focus on a holistic approach considering pricing, purity, size, storage, transportation and distribution in view with the legal framework of contaminants and eco-toxicity. This will help to develop an added value P rich product that can be used as a supplement to prevailing nutrient supply system (Kataki et al., 2016).

8. References

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