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Technology for production of micro-nano bubbles and free radicals with high-voltage discharge in high frequency electromagnetic pulses, in liquid, ultrasonic waves and advanced electro-oxidation



NEPTUNE project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691554

- The Consortium :

SC Kema Tronic SRL : Romanian *SME* , specializing in the field of wastewater treatment, sewage sludge treatment, with a reference of more than 200 wwtps.

SC OST Grup SRL: Romanian *SME* specializing in delivery, mounting and commissioning of innovative equipments, for many wwtps in Romania.

- The project sector: WASTEWATER TREATMENT

- The grants received from NEPTUNE: 75 000 EUR



Solutions and Benefits

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- *The main issue the project was designed to solve:*

The hypothesis : a new technology for production of micro-nano bubbles and free radicals with high-voltage discharge in high frequency electromagnetic pulses in liquid, ultrasonic waves and advanced electro-oxidation will have dramatic effects on wastewater treatment. A combined module was tested to assess COD degradation, wastewater/ sludge sterilization and its feasibility in terms of efficiency, costs, environmental and social impact.

- *Main innovations:*

Technology for production of micro-nano bubbles and free radicals with high-voltage discharge in high frequency electromagnetic pulses in liquid, ultrasonic waves and advanced electro-oxidation

-a breakthrough, low-cost, low-carbon, chemical-free, green solution for treating industrial and municipal wastewater.

-no/less sludge generation.

The module is presented below:

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PILOT PLANT FOR WASTEWATER AND SLUDGE TREATMENT (without activated sludge)



DETAILS:

- HIGH-VOLTAGE DISCHARGE WITH HIGH FREQUENCY PULSES IN LIQUID, WITH NON-THERMAL PLASMA PRODUCTION – VOGELSANG
- ULTRASONIC DISINTEGRATION – ULTRAWAVES
- AIR MICRO-NANO BUBBLES PRODUCTION
- “AOP” (ADVANCED OXIDATION PROCESS) WITHOUT ACTIVATED SLUDGE

EFFECTS:

- FREE RADICALS PRODUCTION ($\text{OH} \cdot$ and $\text{O} \cdot$) AND ADVANCED OXIDATION
- BREAK-DOWN OF ORGANIC LOAD WITH “AOP”
- REMOVAL OF HORMONES, PESTICIDES, HERBICIDES
- NO MORE SLUDGE PROBLEMS
- STERILIZATION OF TREATED WASTEWATER



Solutions and Benefits

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Main cross-sector solutions

- High voltage field used to treat wastewater, to break down organic substances, hormones, pesticides
- Ultrasound waves with cavitation used to treat wastewater, to break down organic substances, hormones, pharmaceutical substances, pesticides.
- Production of micro-nano bubbles and free radicals with high-voltage discharge with high frequency electromagnetic pulses in liquid, ultrasonic waves and advanced electro-oxidation
- Electrochemical technology used to treat wastewater, by the effect of generated oxidants, breaking down organic substances, hormones, pharmaceutical substances, pesticides. Air is also used to create oxidants (atomic oxygen); this has never been used for wastewater
- Irrigation with treated wastewater



Solutions and Benefits

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The IPR created

- A major achievement : drafting and submitting an opinion report to the relevant authority, with the official positive response of patentability for this new technology:

Technology for production of micro-nano bubbles and free radicals with high-voltage discharge with high frequency electromagnetic pulses in liquid, ultrasonic waves and advanced electro-oxidation

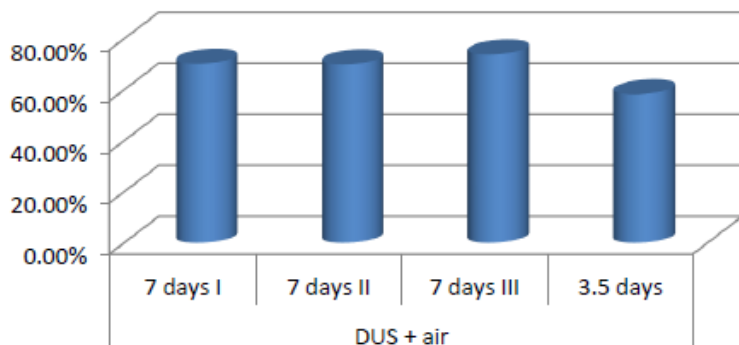
- The Patent request officially submitted and recorded.

The results of the new technology are shown in the diagrams below, for WASTEWATER and SLUDGE (TWAS)



1. WASTEWATER

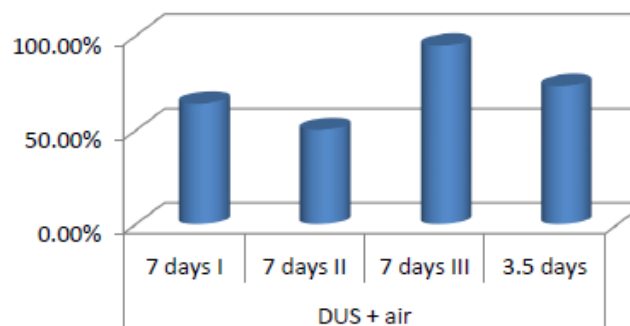
COD



Wastewater treatment with ultrasonic disintegration and micro-nano bubbles

COD removal efficiency : up to 74%

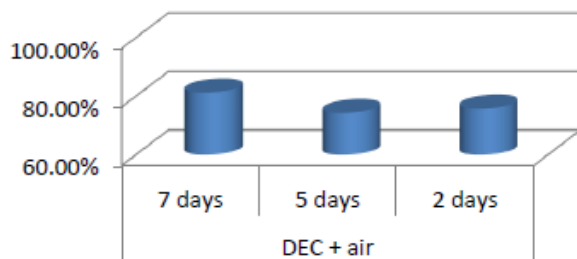
BOD



Wastewater treatment with ultrasonic disintegration and micro-nano bubbles

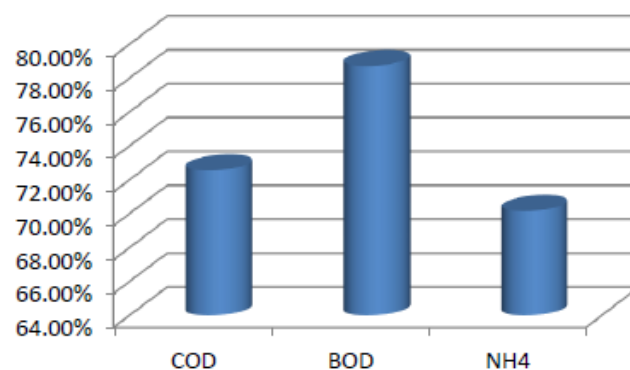
BOD removal efficiency : up to 95%

COD



Wastewater treatment with High-voltage discharge in high frequency electromagnetic pulses in liquid treatment + and micro-nano bubbles

COD removal efficiency : up to 82%



Wastewater treatment with ultrasonic disintegration treatment + high-voltage discharge in high frequency electromagnetic pulses in liquid treatment + micro-nano bubbles – duration 8 days

COD removal efficiency : up to 74%

BOD removal efficiency : up to 78%

NH4 removal efficiency : up to 69%



Solutions and Benefits

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Conclusions

Production of micro-nano bubbles and free radicals with high-voltage discharge in high frequency electromagnetic pulses in liquid seemed to yield the highest efficiencies on its own for COD and BOD

High NH_4 removal was observed after US treatment, but not after high-voltage discharge in high frequency electromagnetic pulses in liquid;

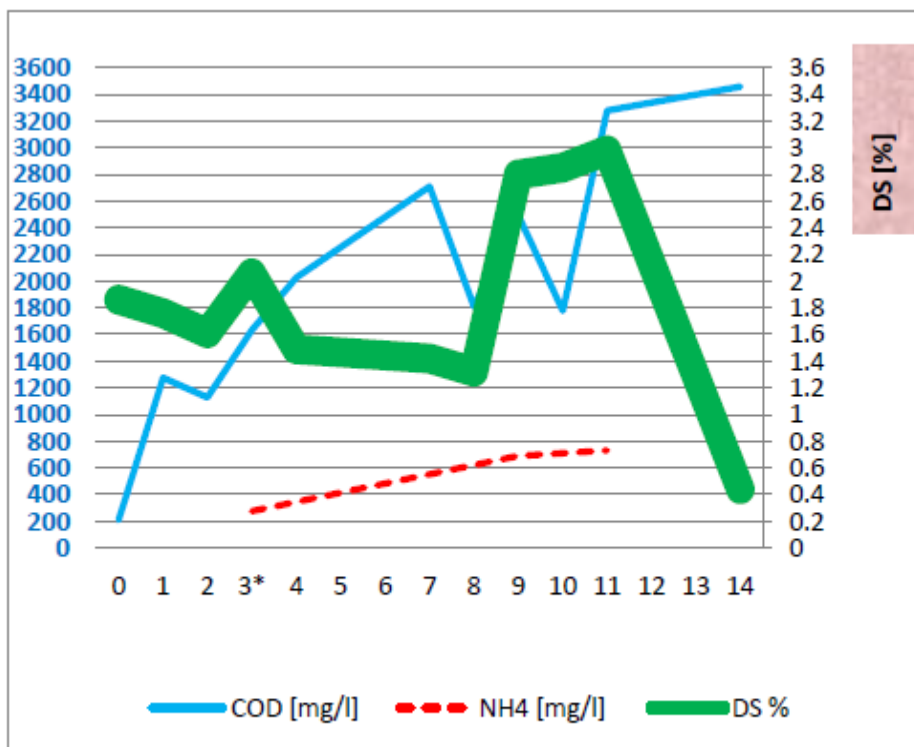
Therefore both types of disintegration are required for tertiary treatment of wastewater , working together in the proposed hybrid system.

The process has high removal efficiency even at low wastewater temperatures



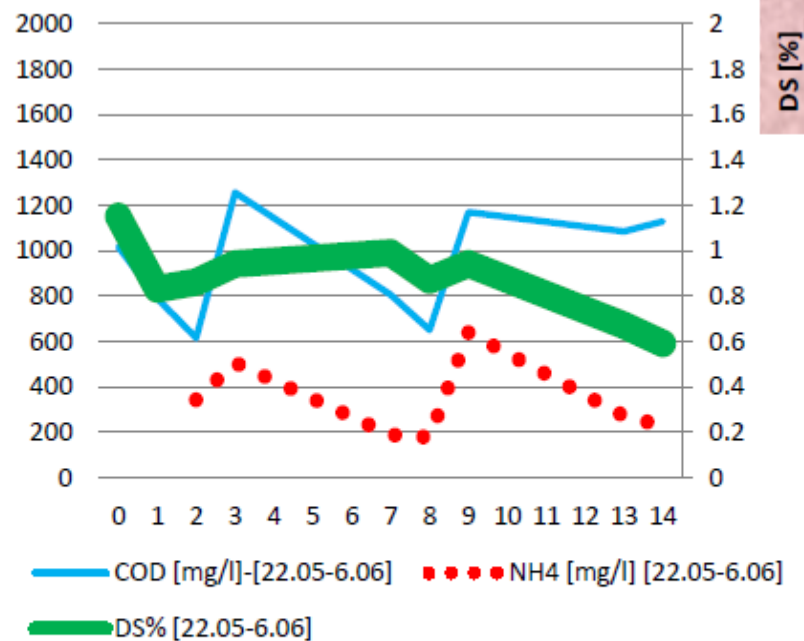
2. SLUDGE (TWAS)

Technology: MNB+High-voltage discharge in high frequency electromagnetic pulses in liquid+ ultrasonic disintegration



Sludge removal: 78%

Treatment duration: 14 days



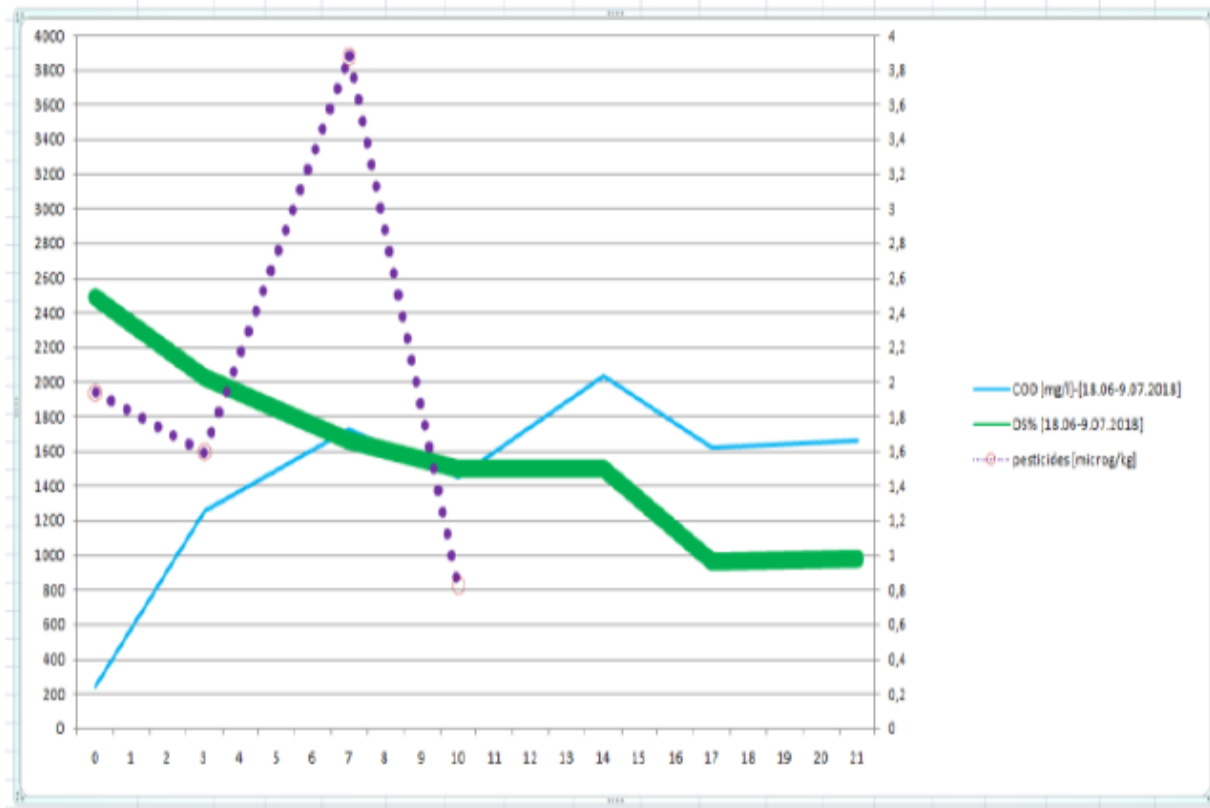
Sludge removal: 49%

Treatment duration: 14 days



2. SLUDGE (TWAS)

Technology: MNB+High-voltage discharge in high frequency electromagnetic pulses in liquid+ ultrasonic disintegration



Sludge removal: 61%
Treatment duration: 21 days

Conclusion:

Sludge can be reduced in proportion of 49 % – 78 %
Pesticides are removed 100%

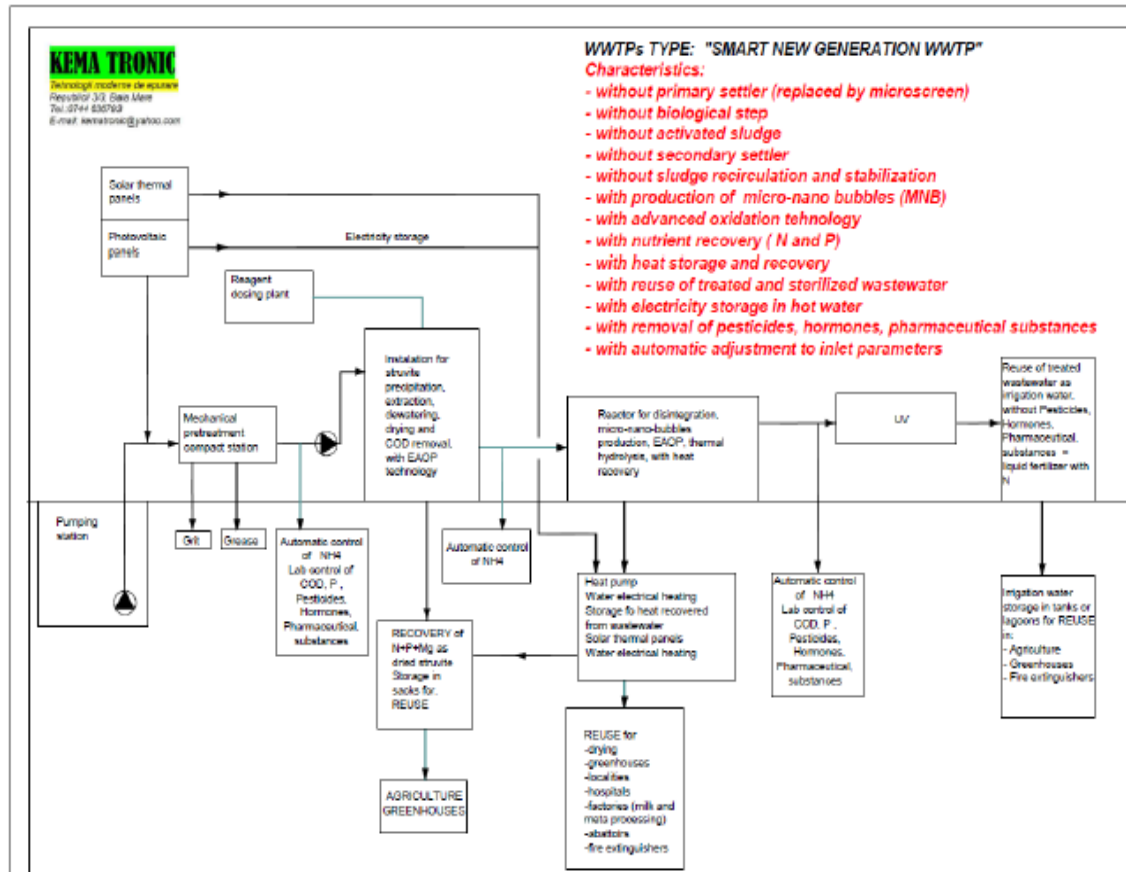


• Benefits of the project solution to customers and other stakeholders

This technology will be the base for the following next steps, benefiting all types of customers and *stakeholders*:

1. Design of the pilot wastewater treatment plant **SMART NEW GENERATION WASTEWATER TREATMENT PLANT**, capacity 900 PE and the series without biological treatment, with lower capital and OPEX costs, without biological sludge production, less environmental impact than conventional wwtps.

NEW WWTPs

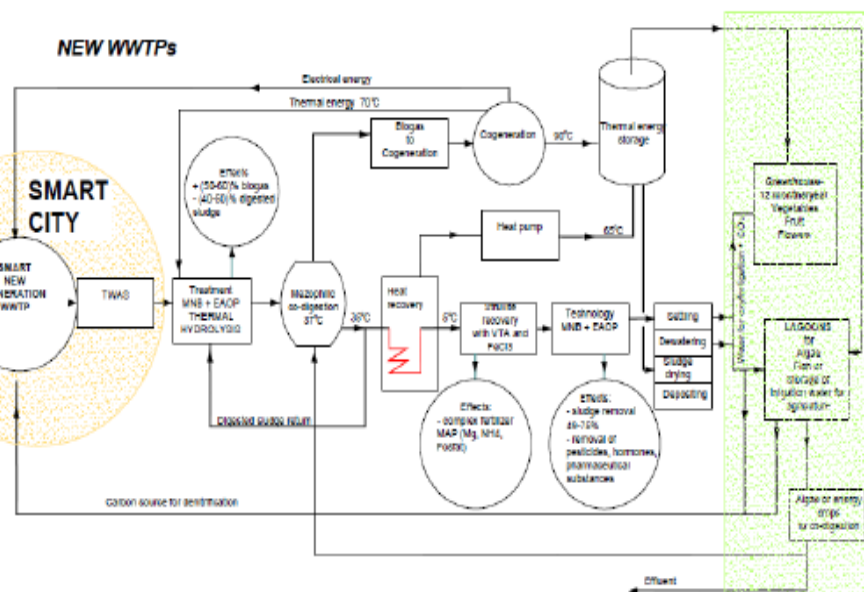


At the end of 2018 we will commission the first NEW GENERATION WASTEWATER TREATMENT PLANT, resulted from conversion of a classical WWTP, at Dumbrava locality, Romania (910 PE)

2. Smart city concept including SMART NEW GENERATION WWTP

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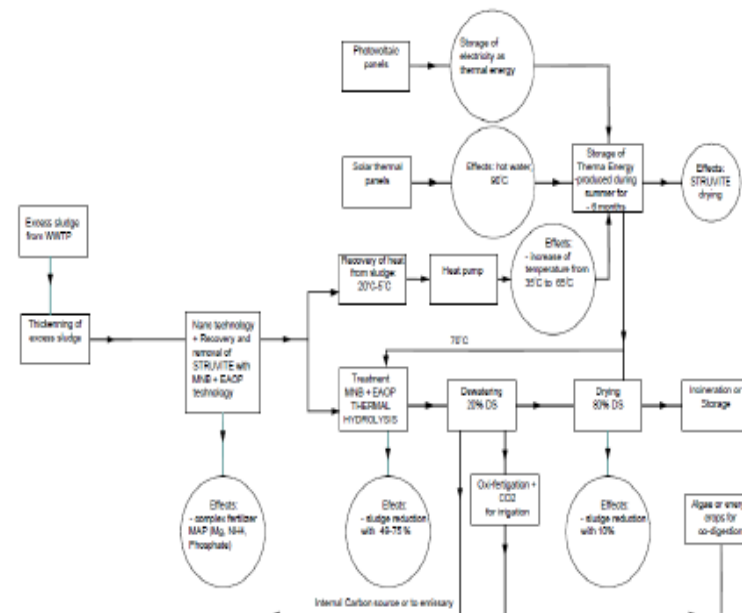
**SMART CITY WITH SMART NEW GENERATION WWTP
IN CIRCULAR ECONOMY
LOCALITIES BIGGER THAN 20.000 PE**



3.Design of technical documentation

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**EXISTING WWTPs WITH AEROBIC SLUDGE
TREATMENT IN CIRCULAR ECONOMY
FOR LOCALITIES SMALLER THAN 20.000 PE**

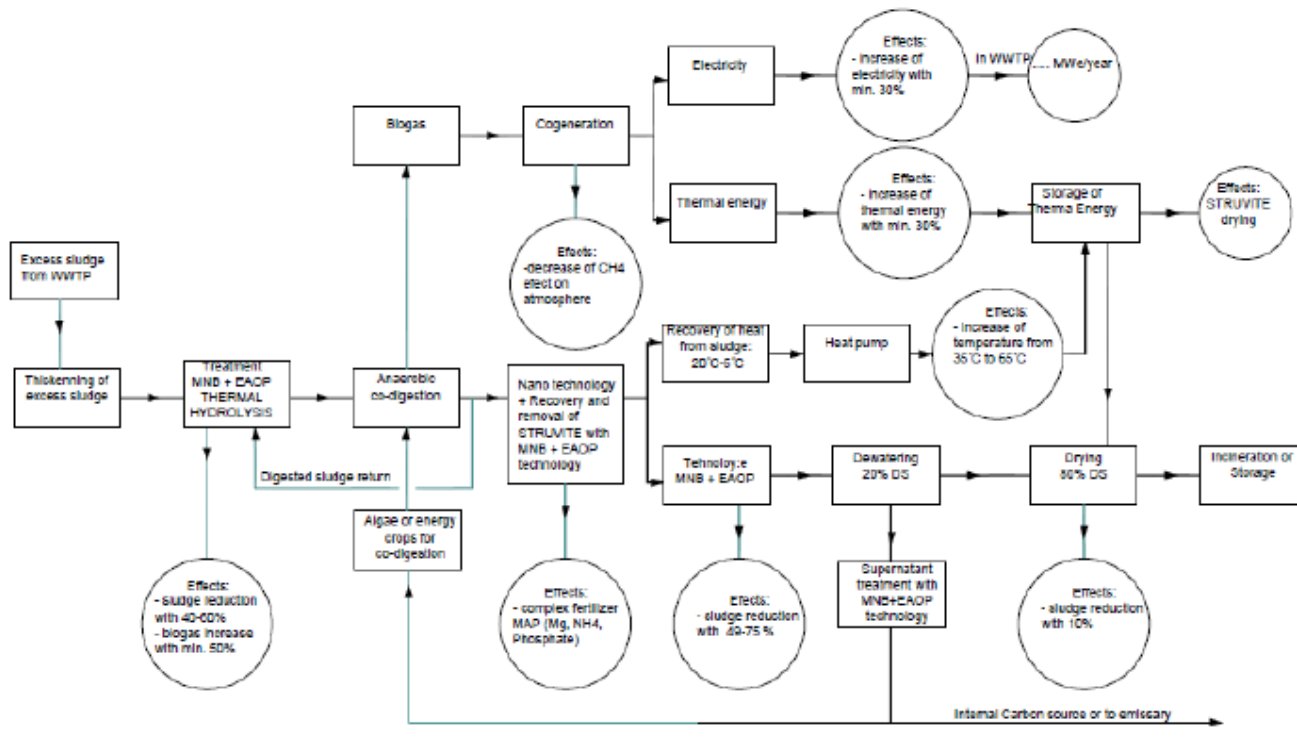




4. Design of technical documentation for wwtps with aerobic sludge treatment within circular economy for localities smaller than 20 000 PE

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EXISTING WWTPs WITH ANAEROBIC SLUDGE TREATMENT IN CIRCULAR ECONOMY FOR LOCALITIES BIGGER THAN 20.000 PE



5. Design of execution documentation for:

- TWAS treatment installation with MNB and EAOP technology, complete with thermal hydrolysis
- Struvite extraction installation from digested sludge and carbon removal with MNB-EAOP technology
- Pilot installation for elimination or reduction of digested sludge, with MNB-EAOP technology
- Pilot installation for enrichment of treated wastewater with O₂ and CO₂, to obtain irrigation water for oxi-fertigation



Benefits of the project solution to the Environment

Our innovation would ensure the following, all in the context of circular economy of the wwtp:

- an energy self-sufficient wastewater treatment
- zero discharge facilities
- Reducing the environmental impact of sewage sludge management
- Lowering the wwtp's carbon footprint
- Improving the quality of the aquatic environment
- treated wastewater with nitrogen and phosphorus used for irrigation , for vegetable and fruit production, using also the heat from the wastewater treatment plants.
- Energy crops and algae can be produced for co-digesting with sludge for renewable electricity and thermal energy production
- The proposed technology would save 50% of electrical energy used to treat wastewater
- Reducing energy use is a solution to the problem of reducing emissions of greenhouse gases.

The proposed technology uses no chemicals during operation



Neptune Contribution

-On the project

This innovative project could not have been implemented without the Neptune support

The grants were used for the following :

- Design of small-scale prototype concept, technology and installation
- Acquisition of sonication equipment with sonication control panel
- Acquisition of blowers and installation for fine bubble production
- Acquisition of small-scale prototype control panel
- Final mounting of small-scale prototype
- Transport to company running the test with wastewater/ sludge from Cluj-Napoca wwtp
- Management of research activity
- Conclusion, reports
- Promoting and first steps of commercialization of the new product

-On the consortium

- Five new jobs within the design, production, and sales departments of our companies
- An increase of 30 000 euro/year of each company's turnover (as of the first year of commercialization).

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