# PHISYCAL AND CHEMICAL TECHNIQUES FOR REMOVING NITROGEN AND PHOSPHORUS FROM RESIDUAL WATERS

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***Abstract***
*The present paper brings to the attention of the specialists in the field the main physical and chemical techniques for removing nitrogen and phosphorus from residual waters, providing exploitation details for each technique. These techniques belong to the category of advanced sewage treatment technologies. The serious problems related to water protection led to some severe restrictions regarding the concentration level allowed in the purified effluent discharged in the natural outlets.*

**Key words:** residual water, purified effluent, conventional sewage, wastewater treatment plants, removing.

## INTRODUCTION

According to residual pollutants that should be removed and to technical-economical analyses of solutions, there are a multitude of possible combination of procedures and individual operations.

Phosphorous and nitrogen are the main nutrients existent in the effluents treated mechanic-biologic, that are important regarding the advanced treatment. Discharges of residual water containing N and P can accelerate the lakes and accumulations eutrophication and can stimulate the development of algae and aquatic plants.

Besides the fact that they produce an unpleasant aesthetic sight, the presence of algae and aquatic vegetation can affect the use of water resources, especially when they are used as resources for water supply, fish breeding and entertainment.

Significant concentrations of N in the effluent treated mechanic-biologic can have adverse effects including the consumption of oxygen dissolved in the outlets, leading to a toxic aquatic environment, influencing the efficiency of chlorine disinfection, endangering public health and affecting the possibility of reusing the treated residual water.

Nutrients control has become an important objective regarding water quality management and treatment stations design.

## NUTRIENTS CONTROL STRATEGIES

When choosing the nutrients control strategies it is important to establish: the characteristics of raw residual water, the type of the existing treatment station, the concentrations imposed regarding N and P for the effluent and the necessity of reducing the nutrients seasonal or permanently.

Nutrients control ways can imply the introduction of an individual process for controlling a certain nutrient (for example, $Al_2(SO_4)_3$ addition for P precipitation) or can imply the integration of nutrients removing process in the biological treatment phase [6, 9].

On the method and technology chosen, depends the fulfillment of demands imposed, referring to effluent quality, flexibility in operation and cost. Initially, various types of treatment gave used chemical, physical and biological systems for quantities limiting and control or nutrients form from the treatment station effluent. The most often used methods were:

- Nitrification in biological phase for ammonic oxidation;
- Biological de-nitrification using methanol for retaining N;
- P chemical precipitation.

In recent years, a series of biological procedures were developed, centered either on individual retaining of nitrogen or phosphorous or on simultaneous retaining of N and P. These procedures were highly appreciated by specialists in the area, because massive use of chemical reagents has been eliminated or reduced substantially, with all the economical consequences resulting from these.

## NITROGEN CONTROL AND REMOVAL

In untreated residual water, N is found as ammonia or organic nitrogen, both soluble, as micro-particles. Soluble organic nitrogen is often found as urea or amino acids.

Untreated residual water contains less or at all nitrites or nitrates. A part of organic particles are retained by primary decantation [2, 7]. During the biological treatment, the most numerous particles containing substances based on organic nitrogen are transformed in ammonic or other organic forms.

A part of ammonia is assimilated in the biomass cells. The greatest part of N from secondary effluent is found as ammonic.

In table 1 is shown the effect of different operations and treatment procedures on organic nitrogen, ammonia and nitrates found in residual water.

*Table 1*

The effect of different operations and treatment procedures on nitrogen based compounds [8, 10]

| Treatment operation or procedure | | N based compounds | | | N total retained* % |
|---|---|---|---|---|---|
| | | N organic | $NH_3$-$NH_4^+$ | $NO_3^-$ | |
| **CONVENTIONAL TREATMENT** | | | | | |
| 1 | Mechanic treatment | 10–20% | no effect | no effect | 5–10% |
| 2 | Biologic treatment | 15–50%** | < 10% | small effect | 10–30% |
| **BIOLOGIC TREATMENT** | | | | | |
| 1 | Bacterial assimilation | no effect | 40–70% | slab | 30–70% |
| 2 | De-nitrification | no effect | 40–70% | 80–90% | 70–95% |
| 3 | Nitrification | limited effect | → $NO_3$ | no effect | 5–20% |
| 4 | Oxidation ponds | partial transformation in $NH_3$-$NH_4^+$ | partially reduced through flash distillation | partially reduced through nitrification /de-nitrification | 20–90% |
| **CHIMICAL PROCEDURES** | | | | | |
| 1 | Chlorination at breakpoint | uncertain | 90–100% | no effect | 80–95% |
| 2 | Chemical coagulation | 50–70% | small effect | no effect | 20–30% |
| 3 | Ions exchangers selective for ammonia | small, uncertain | 80–97% | no effect | 70–95% |
| 4 | Ions exchangers selective for nitrates | small effect | small effect | 75–90% | 70–90% |
| 5 | Adsorption on coal | 30–50% | small effect | small effect | 10–20% |

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|---|---|---|---|---|---|
| PHYSICAL OPERATIONS | | | | | |
| 1 | Filtration | 30–95% from N organic in suspension | small effect | small effect | 20–40% |
| 2 | Flash distillation | no effect | 60–95% | no effect | 50–90% |
| 3 | Electro dialysis | 100% for N organic in suspension | 30–50% | 30–50% | 40–50% |
| 4 | Inverted osmosis | 60–90% | 60–90% | 60–90% | 80–90% |

[*] according to the initial concentration in N total of influent.
[**] soluble organic N, as urea or amino-acids, it is reduced substantially through the secondary treatment phase.

## PHOSPHOROUS CONTROL AND REMOVAL

For most part of residual water, around 10% of P concentration corresponding to the insoluble part, is normally retained through primary decantation.

Exception for the quantities incorporated in the cellular tissue; in biological phase, the reduction is minimum, because P, present in residual water after primary sedimentation, is soluble. Table 2 shows the effects of conventional treatment or other treatment procedures regarding P reduction [1, 3, 4, 5].

*Table 2*

The effects of different treatment operations and procedures on retaining phosphorous

| | Treatment operations or procedures | P reduction in system, % |
|---|---|---|
| CONVENTIONAL TREATMENT | | |
| 1 | Mechanical treatment | 10 – 20% |
| 2 | Activated sludge | 10 – 25% |
| 3 | Bio-filters | 8 – 12% |
| 4 | Biological filters with discs | 8 – 12% |
| BIOLOGIC REDUCTION OF PHOSPHOROUS | | |
| 1 | P reduction on water surface | 70 – 90% |
| 2 | P reduction on sludge surface | 70 – 90% |
| COMBINED BIOLOGIC REDUCTION OF NITROGEN AND PHOSPHOROUS | | |
| 1 | Combined biologic reduction of N and P | 70 – 90% |
| CHEMICAL REMOVAL | | |
| 1 | Salt precipitation | 70 – 90% |
| 2 | Lime precipitation | 70 – 90% |
| PHYSICAL REMOVAL | | |
| 1 | Filtration | 20 – 50% |
| 2 | Inverted osmosis | 90 – 100% |
| 3 | Adsorption on coal | 10 – 30% |

P removal can be done through physical, chemical and biological means. Chemical precipitation (using Fe and Al salts, or lime) has already been used for P reduction. The biological treatment methods are based on simulating the microorganisms which will take more P than needed for cellular development. Lately, the development and application of biologic techniques for reducing P was preferred, instead of chemical precipitation.

When obtaining an effluent with low concentrations regarding P (generally under 1 mg/l) is necessary, filtration is used in combination with other biologic or chemical procedures. Other physical procedures, such as ultra-filtration and inverted osmosis are important in retaining P but are still applied, for removing the dissolved inorganic substances.

## CONCLUSIONS

### Advantages and disadvantages of chemical and physical nitrogen removal

**Stripping procedure**

**Advantages:** This procedure can be used for the selective retainment of ammonia. It is the most often used procedure when a seasonal removal of ammonia is necessary. It's combined with phosphorus removal by utilizing calcium oxide. The effluent's nitrogen concentration can be kept within the accepted limits. It is not sensitive to toxic substances.

**Disadvantages:** The procedure is influenced by temperature. The ammonia's solubility increases as the temperature decreases. The amount of air necessary is variable. Creates steam and freezes at low temperatures. The ammonia's reaction with sulfoxide can cause air pollution. The process frequently utilizes calcium oxide to control the pH, which leads to increased purification costs and maintenance problems. Has the potential to release dangerous gases.

**Chlorination at breakpoint procedure**

**Advantages:** With adequate supervision, ammoniacal nitrogen can be entirely oxidized. It can be utilized after other processes of nitrogen retainment with a finishing role. Can be compared to the disinfection of the effluent. Requires limited space. It is not sensitive to toxic substances or temperature. Requires low costs and is adaptable to existing purification stations.

**Disadvantages:** Can produce residual chlorine in large quantities, which is toxic for the sea life. The used water contains a large variety of substances, requiring chlorine, which increases treatment costs. The procedure is sensitive to pH, which affects the required dosages. Exploitation costs increase. The forming of trihalomethanes affects the quality of water sources. It is possible that the accepted effluent limits regarding nitrogen concentration cannot be enforced. It requires heightened pH control so that trichlorine nitrate does not form. It requires highly trained operators.

**Ion exchangers procedure**

**Advantages:** Can be used where climatic conditions prevent biological nitrification and where strict effluent requirements are in place. It creates a recyclable product (watery ammonia). It can ensure that the effluent's nitrogen concentration is within standard requirements. Easy to keep track of quality.

**Disadvantages:** It is necessary to start a filtration treatment first to prevent excessive loading due to flocks accumulating. Increased concentrations of other cations will diminish ammonia retainment potential. Complete regeneration might require another functional unit. Both initial and running costs are high. Requires highly trained operators.

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