# THEORETICAL ASPECTS OF ADVANCED METHODS OF WASTEWATER TREATMENT IN ORDER TO ELIMINATE POLLUTANTS FROM SURFACE WATERS

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**Abstract**

In this paper, the authors, based on extensive research literature, highlight some aspects of advanced biological treatment processes by providing advanced technological efficiency in order to address surface water pollution. Natural sources of pollution of surface water, are mostly of their permanent sources. The quality of surface water to discharge effluent from wastewater treatment is influenced by poorly treated sewage, because they contain pollutants. Are the most dangerous pollutants are organic because they under certain conditions and concentrations of the fermentation. The composition of wastewater, the organic fraction is made up of carbon and nitrogen fraction. Effluents after the biological stage is classical in its composition different forms of nitrogen (ammonium salts, nitrites, nitrates, organic nitrogen) and phosphorus (phosphorus organic orthophosphates, polyphosphates) that reached the receiver are easily assimilated by the algae, contributing directly increase the rate of eutrophication of standing or slow flow. Research conducted in recent years by specialists in our country show a significant increase in these nutrients in surface water and groundwater. Tertiary or advanced stage of wastewater treatment is aimed at the elimination of wastewater nitrogen compounds, phosphorus and other chemicals remaining in water after using the biological processes of nitrification - denitrification. The purpose of this paper is to highlight the presence of pollutants in wastewater discharge into the emissary of insufficiently treated by conventional methods, the harmful effects of these pollutants on the environment and presentation of advanced treatment methods to resolve the problem.

**Key words**: surface, wastewater, emissary, purge, pollutant

The composition of wastewater contaminants predominate as the main organic substances (carbohydrate, protein, lipids), their transformation products and a variety of combinations of these substances. Nitrogen, phosphorus, carbon and oxygen are important nutrients for living matter. Its absence makes it impossible to increase the organisms and their presence above the permissible limits are important sources of pollution. If the streams are enriched with nitrogen and phosphorus compounds resulting excessive growth of algae and aquatic plants, a phenomenon known as eutrophication. Retention of nitrogen and phosphorus from wastewater is a major concern worldwide because water sources are becoming fewer and more polluted.

Problems caused by the existence of nitrogen and phosphorus compounds above the permissible limits in mechanical-biological treated wastewater led to imposing severe limitations on effluent concentrations of these pollutants download natural emissaries. These limitations can not be provided in a treatment plant with conventional methods of wastewater treatment, therefore it follows the adoption of technologies to the characteristics of wastewater to be treated and the local environmental conditions can provide a appropriate effluent quality standards. Statistical analysis of the main sources of wastewater revealed that 77.4% of waste water from the main sources of pollution have reached the natural receptors untreated or insufficiently treated (Tobolcea V., 2010). In this respect require advanced treatment technologies designed to remove elements with character fertilizer by nitrification-denitrification processes for removing nitrogen and phosphorus compounds.

## POLLUTANTS IN SURFACE WATERS

Human impact on the environment cause a high degree of surface water pollution due to discharge untreated wastewater properly. The action exerted on receptors wastewater depends on their composition and concentration of pollutants. For determining the composition of wastewater discharged into surface water and in laboratory emissary characteristic is determined based on which provides information on pollution of wastewater, surface water and the conditions under which they should be treated, that is used. In

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(tab.1) lists the categories of substances and polluting materials in wastewater composition, in terms of physical condition and their nature (Tobolcea V., 2004).

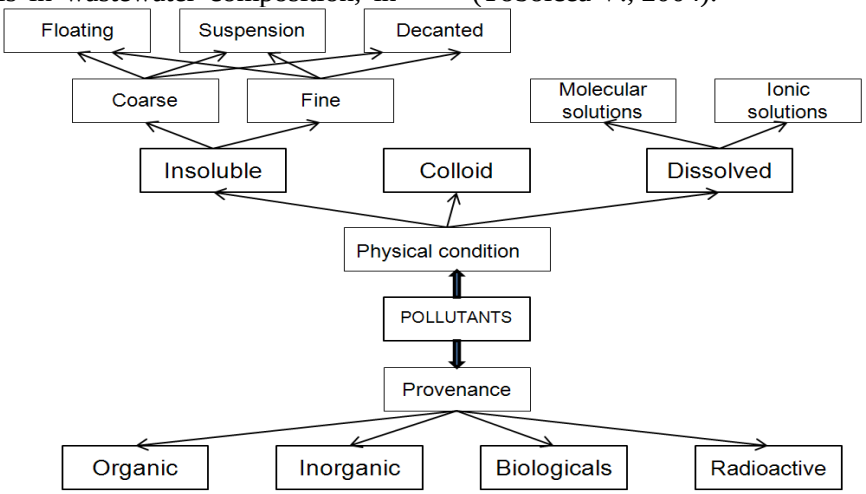


Figure 1 **Classification of pollutants from wastewate**

Under certain conditions and concentrations of these pollutants can change water characteristics become sources of pollution and degradation of surface waters. Most dangerous are the pollutants are organic because they come in fermentation emphasizing eutrophication. They can be plant or animal origin. Most of plant have a high content of carbon. The nature of animal, chemically characterized by a high nitrogen content, appear in municipal wastewater in the wastewater from the fishing industry, slaughterhouses, dairy. The composition of wastewater, the organic fraction is composed of carbon dioxide and nitrogen fraction.

Nitrogen concentration in wastewater entering the treatment plant is 90% and is in the form of ammonium ions or organic compounds instability, later transformed into ammonium ions. Total nitrogen in wastewater can be found in the form of free ammonia (60%), organic nitrogen (35%) and salts of nitrites and nitrates (5%). Organic nitrogen (proteins, amines, amino acids) is rapidly converted into ammonia and ammonia compounds. In effluents after the biological step is classical residual nitrogen in various forms, predominantly nitrate reached the receiver which stimulates eutrophication. Phosphorus, nitrogen compounds are assimilated with easily by the algae, contributing directly to increased rate of eutrophication of standing or slow flow. The concentration of these organic substances in wastewater can be determined by the oxygen necessary for their decomposition. Conventional wastewater treatment has a 15-40% efficiency in terms of elimination of total nitrogen and total phosphorus in the removal of 10-30% (Braha Al., 1988). Recent research highlighted in the literature (Eckenfelder, 1995) show that treatment plants equipped with a mechanical and biological efficiency of 5-25% total nitrogen removal, that much of the nitrogen compounds reach the receptors with consequences negative environment. In (tab. 1, 2) is shown effective removal of N and P concentrations in the effluent in the first stage of treatment.

Table 1

**Effective removal of nitrogen**

| Form of N | Concentration of N compounds (mg/dm$^3$) | | | Total average purification efficiency (%) |
|---|---|---|---|---|
| | In wastewater | The primary effluent | The secondary effluent | |
| Organic nitrogen | 10-25 | 7-20 | 3-6 | 30-60 |
| Soluble | 4-15 | 4-15 | 1-3 | 25-40 |
| Insoluble | 4-15 | 2-9 | 1-5 | 40-70 |
| Ammonium | 10-30 | 10-30 | 10-30 | 0 |
| Nitrites | 0-0.1 | 0-0.1 | 0-0.1 | 0 |
| Nitrates | 0-0.5 | 0-0.5 | 0-0.5 | 0 |
| Total nitrogen | 15-50 | 15-40 | 15-40 | 15-40 |

The effects of nitrogen on the environment is manifested in the watercourse where treated or untreated wastewater are discharged. Unionized ammonia is toxic to aquatic fauna, for bringing it to the stage of non-toxic ammonium is necessary to decrease the pH optimum wastewater pH=8. Ammonia present in wastewater require oxygen consumption of 4.6 mg / mg ammonium nitrate to lower conversion of the concentration of dissolved oxygen in waters emissary (Negulescu, 1978). Phosphorus is the limiting factor of plant growth mainly with the effect of surface water pollution by eutrophication. Research conducted in recent years by specialists in our country show a significant

increase of these nutrients in surface waters and groundwater. Therefore, the values of N and P concentrations in the effluent, the above must fall within permissible levels outlined in the regulations of our country, presented in (tab.3).

Table 2

**Effective removal of phosphorus**

| Form of P | Concentration of P compounds (mg/dm$^3$) | | | Total average purification efficiency (%) |
|---|---|---|---|---|
| | In wastewater | The primary effluent | *The secondary effluent* | |
| Organic phosphorus | 1-3 | 0.5-2 | 0.5-1 | 30-60 |
| Orthophosphate | 2-8 | 1-7 | 1-8 | 0-40 |
| Polyphosphate | 2-8 | 2-8 | 1-3 | 20-60 |
| Total phosphorus | 4-14 | 3-12 | 3-11 | 10-30 |

Table 3

**The maximum allowable to discharge into natural receivers**

| Quality indicator | Maximum allowable value (mg/dm$^3$) |
|---|---|
| Ammonium $NH_4$ | 2.0 (3.0) |
| Total nitrogen N | 10.0 (15.0) |
| Nitrate $NO_3$ | 25.0(27.0) |
| Nitrite $NO_2$ | 1.0(2.0) |
| Total phosphorus P | 1.0(2.0) |

## THE EFFECTS OF EUTROPHICATION

Called eutrophication and pollution of natural water courses, is manifested by the explosion of aquatic flora under the influence of nitrogen and phosphorus compounds present. When conditions are created for these types of nutrient uptake, especially in lakes and water courses which has a slow flow, eutrophication effects consist mainly in a rapid development of vegetation and other aquatic organisms, followed by decreasing concentration and increased dissolved oxygen content of organic solids. Algae is a real danger for the balance of aquatic ecosystems in a short time when conditions favored development. Direct consequences of eutrophication of surface waters due to phosphorus and nitrogen present in high concentrations are excessive growth of algae and blue green, reduced water transparency, high consumption of dissolved oxygen, up to 100% of the initial concentration of water, release of hum, missing of small fish species, increasing density of aquatic plants in shallow waters.

Another effect produced enegativ from eutrophication is the size of nitrate concentration in discharge waters from sewage envoy dilution without adequate time to dry and wastewater flow rates. Currently 30-40% of surface waters are affected to a lesser or greater eutrophication. Removal of nutrients in water is essential for a low impact on the environment WWTP by minimizing the risk of eutrophication of natural courses.

## ADVANCED METHODS TO REMOVE NUTRIENTS

Tertiary or advanced stage of wastewater treatment aims to finish wastewater purification by removing nitrogen compounds, phosphorus and other chemicals remaining in water after the biological step. Worldwide there are many technological schemes with activated sludge wastewater treatment that can ensure a high content of nitrogen compounds, phosphorus compounds compounds have the effect of eutrophication of natural waters.

Table 4

**Advanced treatment processes to remove pollutants**

| Substances removed | Advanced process of elimination |
|---|---|
| Nitrogen | biological processes (nitrification / denitrification) or physicochemical (air stripping, chlorination to break point and ion exchange). |
| Phosphorus | procedures identical to those for nitrogen (nitrification and denitrification) or the chemical precipitation. |
| Toxic substances | Processes activated carbon by chemical oxidation or with a mixture of activated sludge and powdered activated carbon. |
| Refractory substances | |
| Dissolved inorganic substances | Chemical precipitation, ion exchange, electrodialysis, reverse osmosis and by ultrafiltration. |

Retention of nitrogen and phosphorus from wastewater is achieved through processes of nitrification -denitrification, to prevent the negative impact of effluent discharge in emissary.

## THE PROCESS OF NITRIFICATION

Nitrification process is carried out using nitrifying bacteria that oxidize ammonia to nitrate successively with intermediate formation of nitrite. Biochemical reactions take place in two stages. The first step is the oxidation of ammonium ion to nitrite according to reaction (eq.1). This reaction is carried out by bacteria of the genus Nitrosomonas. The second step is the oxidation of nitrite (nitrite) to nitrate according to reaction (eq.2). This

reaction is carried out by bacteria of the genus Nitrobacter. Both bacteria are autotrophic and aerobic.

$$NH_4^+ + \frac{3}{2}O_2 \xrightarrow{Nitrosomonas} NO_2^+ + 2H^+ + H_2O \quad (1)$$

$$NO_2^- + \frac{1}{2}O_2 \xrightarrow{Nitrobacter} NO_3^- \quad (2)$$

Oxidation of ammonium to nitrate requires a large amount of oxygen that is 4.5kg for 1 kg ammonia nitrogen oxidized. The nitrification process consumes 4.57 mg ammonium $O_2$/mg and new cells form about 0.15g/g $NH_3$-N (Dima M., 2002). Nitrification presents a short retention time, low concentration of dissolved oxygen in the aeration basin, low temperature below 10-15$^0$C wastewater, high concentrations of organic and inorganic compounds, extreme values of pH and nutrient deficiency key. Figure (fig.2) are the proportions of nitrogen compounds by biological stage.

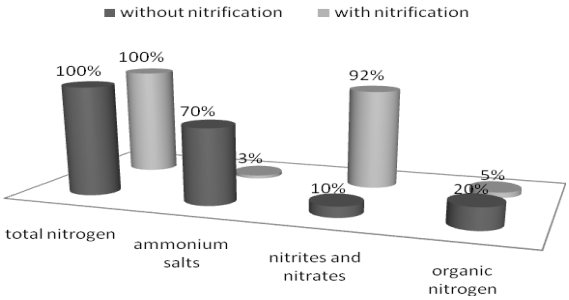


Figure 2 **The proportions of dissolved nitrogen compounds by biological step**

Conditions necessary for the development process involves a pH of 8-8.5 nitrification, an organic loading of 0.15 to 0.25 kg of sludge CBO/kg day, a minimum dissolved oxygen concentration of 2mg/dm$^3$, a time of aeration 5-8 hours a pneumatic aeration (Dima M., 2005).

**THE PROCESS OF DENITRIFICATION**

Nitrification denitrification process continues to remove nitrogen forms consisting of progressive reduction of nitrogen to form molecular nitrogen according to reaction (eq.3). Biochemical processes are produced by bacteria reducing facultative anaerobic species and Pseudomonas Achromobacterium. The process of denitrification from the nitrification takes place in anoxic conditions, organic carbon consumed (BOD) and produce alkalinity.

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2 \quad (3)$$

Location of the entry zone anoxia in biological treatment tank has the advantage that it uses existing organic substances in mechanically cleaned influential as a source of carbon. This process consumes approximately 3.7 g BOD / g $NO_3$-N reduced cell mass and produces 0.45 g and 3.75g to 1.0 g alkalinity reduced $NO_3$-N (Dima M., 2002). Effective denitrification require higher levels of recycling 50% of the $3Q_{influent}$ $2Q_{influent}$.

Conditions necessary for the development process of denitrification involves a pH of 7.5, the lack of dissolved oxygen, retention time of 30-100 minutes depending on temperature and concentration of activated sludge, a high circulation of 1-30% depending on the degree of purification necessary and a mechanical stirring system activated sludge. Biological nitrification and denitrification processes are presented in (fig. 3). When ammonium concentration is high demand from decomposition of organic matter (BOD) hydrogen ions in the oxidation of ammonium to nitrite released lower pH. Following this phenomenon must be done to correct the pH by adding alkali. In order to maintain control of nitrification-denitrification process automation is necessary treatment facilities. In (tab.5) may be found cleaning procedures presented in comparison with conventional paper showing their effectiveness from their use in order to remove compounds of nitrogen present in wastewater (Dima M., 2002). As shown nitrification process has an insignificant effect on the elimination of organic nitrogen in wastewater, so that total nitrogen removal efficiency is the percentage of 5-20%. The degree of removal of total nitrogen in wastewater by denitrification process is 70-95%, provided that there are steps aimed nitrification of ammonia oxidation and nitrogen organic nitrates.

**CONCLUSIONS**

Although mechanical treatment processes, chemical mechanical and mechanical-biological reach good performance, standards are in force lately require more effective treatment in terms of quality of effluent to protect surface water and thus the environment. In order to protect surface water should be removed nitrogen and phosphorus from sewage, nutrients that cause eutrophication. To retain these nutrients is now necessary upgrade the existing sewage treatment or execution of independent steps, namely the tertiary level where there is an advanced wastewater treatment. Implementation step in tertiary wastewater

treatment effluent to obtain a proper permit required values in the current rules.

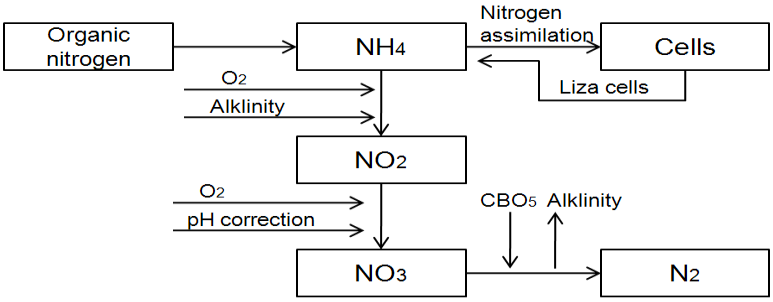


Figure 3 **Scheme nitrification-denitrification processes**

Table 5

**The efficiency of removal of nitrogen**

| Treatment process | | The efficiency of removal of nitrogen compounds | | | Total nitrogen removal efficiency |
|---|---|---|---|---|---|
| | | N organic | $NH_3 – NH_4$ | $NO_3$ | % |
| Conventional treatment | Primary | 10-20% | without effect | without effect | 5-10 |
| | Secundary | 15-50% | to 10% | limited | 10-30 |
| Biological processes | Nitrification | limited | transf. $O_3$ | without effect | 5-20 |
| | Denitrification | without effect | without effect | 80-90% | 70-95 |

Conventional treatment plants can be adapted and supplemented to ensure optimal parameters necessary to carry out nitrification-denitrification processes. The process of nitrification has an insignificant effect on the elimination of organic nitrogen in wastewater, but in combination with denitrification process to obtain a 70-95% efficiency. The processes of nitrification, denitrification specific to this stage that eliminates the problem of surface water pollution to a degree that allows subsequent use for irrigation water, or by adopting advanced technologies become further sources of drinking water. Considering the harmful effect on the nutrients they produce on the environment and the natural emissaries, withheld from their wastewater before discharging their emissaries must be one of the priorities underlying the sizing treatment plants. This paper presents aspects of knowledge need water quality indicators in order to adopt best technological solution for effective treatment. Understanding the origin of nutrients and elimination through advanced technology solutions leads to effective results and beneficial environmental results. Ecological effects of the presence of nitrogen and phosphorus in high concentrations in treated wastewater is significant and negative impact on the environment, which justifies the costs of advanced treatment processes of wastewater.

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