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ANALYSIS OF THE POSSIBLE APPLICATION OF DEAMMONIFICATION TECHNOLOGY IN THE MUNICIPAL WASTEWATER TREATMENT PLANT IN ZABRZE

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Abstract
Due to eutrophication phenomena the modern wastewater plants are obliged to apply highly effective technologies to remove nutrient, i.e. nitrogen and phosphorous, substances. The biological methods to remove nitrogen in the processes of nitrification and denitrifications are successfully used in the main technological line (mainstream). It has been observed, however, that in technical design of activated sludge bioreactor the additional ammonia nitrogen load coming from fermented sludge dewatering effluents was not sufficiently considered. This load, of ca. 20–30% of a total nitrogen inflow, could interrupt the nitrogen removal process. Therefore, the sidestream ammonia nitrogen removal technologies have been widely applied. The operating problems and the ways to solve them in the "Śródmieście" WWTP in Zabrze, resulting from additional nitrogen load, coming from dewatering and thickening effluents, are described in the presented paper. Moreover, preliminary calculations of the DEMON® reactor volume, on the basis of actual nitrogen concentrations in the leachate, in order to implementation deammonification technology in the sidestream on a technical scale were also presented.

Keywords: **Deammonification; Reject water; Nitrogen removal in the sidestream; DEMON system.**

1. INTRODUCTION

Nitrogen is a chemical element commonly occurring in natural environment. Its main source is gaseous nitrogen making up to 80% of the earth's atmosphere and chemically bounded nitrogen being the component of vegetable and animal proteins. The fact that nitrogen undergoes fast and multidirectional transformations is one of its main features (Fig. 1). Such transformation occurs especially in the processes of atrophy and decomposition of organisms and the products of their metabolism (R). Ammonification results in forming of ammonia nitrogen according to the reaction [1]:

$$R-NH_2 + HOH \rightarrow R-OH + NH_3 + \text{energy} \quad (1)$$

Ammonia nitrogen can be assimilated by plants and microorganisms. Then, it is changed into nitrate nitrogen at favourable conditions biological decomposition is a commonly used method to remove inorganic nitrogen compounds from wastewater. Ammonia nitrogen occurring in wastewater is partly used to build new microorganism cells and part of it is removed in the gaseous form. In the initial phase nitrogen compounds are transformed to ammonia. Next, ammonia compounds are oxidized to nitrite and nitrate in aerobic conditions in the process of nitrification. In the fol-

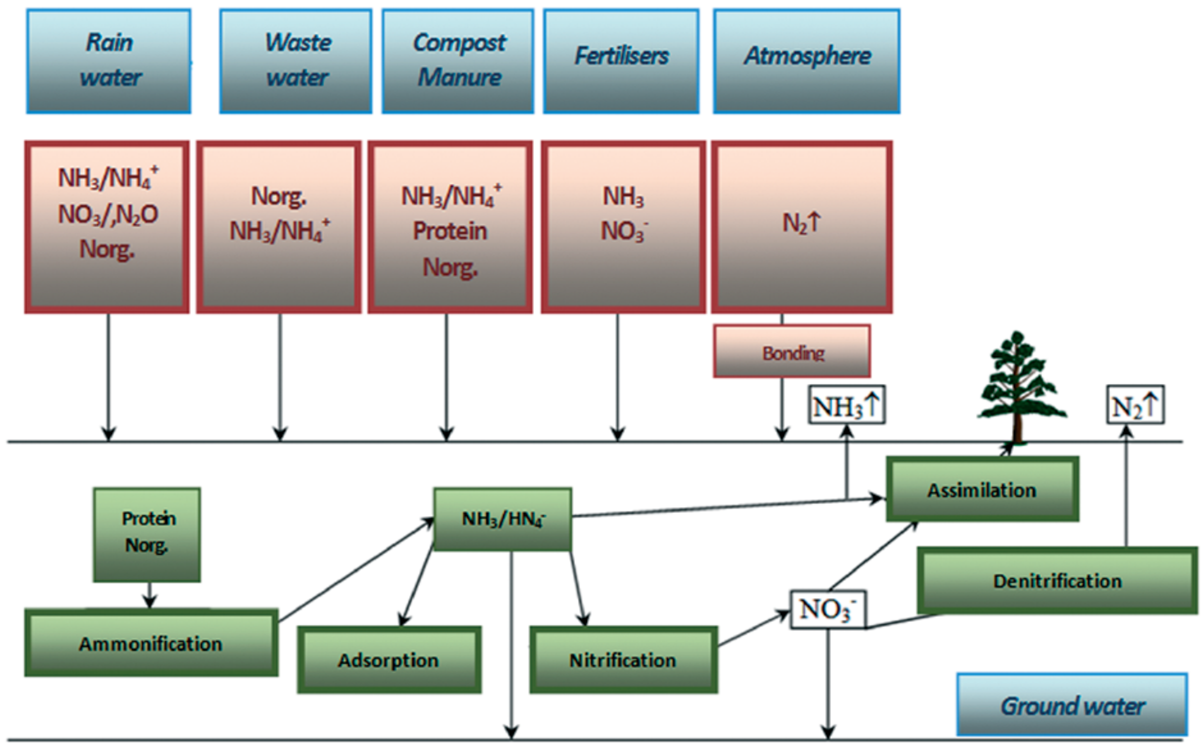

Figure 1.
Nitrogen cycle in the environment [3]

lowing phase they are reduced to molecular nitrogen in anaerobic conditions in the process of denitrification [2, 3].

Nitrogen being a biogenic element is also essential for living organisms. Its deficiency results in growth and metabolism processes disorders. Its excess in the environment, however, is even more dangerous since it could contribute to environmental contamination. High amounts of nitrogen discharged into surface water in various forms including ammonia nitrogen lead to reduction of oxygen concentration in the rivers. It also disrupts the water environment balance resulting in oxygen deficiency which inhibits the self-purification of water. Moreover, ground water resources, used for water supply, could also be contaminated by anthropogenic nitrogen compounds [4].

Therefore, it is commonly agreed that the wastewater treatment plants should be supplied with highly effective technologies of nitrogen removal [5]. The innovative technologies to remove ammonia nitrogen, coming from sludge dewatering and thickening processes, in the sidestream processes are applied to increase efficiency of total nitrogen removal and to reduce its concentration in the treated wastewater discharged into the rivers.

The main application of deammonification is in the nitrogen removal in wastewaters with high NH_4^+ and low COD concentrations (i.e. low COD/N ratio). These types of wastewaters are produced notably in the anaerobic digestion process as reject water [6, 7]. In addition to the anaerobic sludge digester liquors, the sidestream systems may also be applied for the treatment of other warm and high-strength ammonia wastewater with low C:N ratios, such as landfill leachate or some industrial wastewater [8, 9, 10, 11].

Conventional nitrogen removal by denitrification is unsuitable for the treatment of these wastewater streams, because significant amounts of external carbon source (e.g. methanol) will have to be added to increase the COD/N ratio. Deammonification however enables the nitrogen removal of such wastewaters without external carbon source. In wastewater treatment plants (WWTPs), deammonification is widely applied in the separate treatment of reject water from anaerobic digestion of sludge [12]. The typical sidestream deammonification (SD) application in reject water treatment is illustrated in Figure 2.

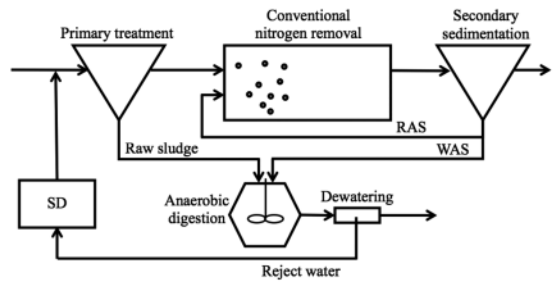

Figure 2.
Typical side stream deammonification (SD) application in a WWTP with activated sludge process [13]. SD: sidestream deammonification; RAS: return activated sludge; WAS: waste activated sludge

Normally, reject water is led to the WWTP mainstream without separate treatment. Deammonification in sidestream can remove up to 90% of the internal nitrogen load in reject water. This way, nitrogen removal process in the WWTP mainstream has more effectiveness removal of nitrogen loads in the influent. Deammonification in sidestream is implemented in full-scale since 2002, when the first application started operation in the Netherlands. This technology is now considered as the most innovative technology for reject water treatment [12]. In the presented paper the operating problems in "Śródmieście" WWTP, resulting from ammonia nitrogen load are described.

Some efforts to find a proper, contemporary solution to this problem are also described and discussed. One of the tested solutions is application of deammonification technology based on DEMON® reactor, applied in the technical scale. The main idea of the applied technology is to treat nitrogen riched effluent before it comes to a mainstream [14, 15, 16].

These innovative methods based on activated sludge are widely applied in such the process, e.g. SHARON®, BABE®, SHARON®-ANAMMOX® and also DEMON®. These methods clearly show better and better results to enable its wide application all over Europe (Austria, Switzerland, Germany) and also in Poland (since 2015, a DEMON® system, WWTP "Kujawy", Krakow, south of Poland) [15].

Nowadays DEMON technology seems to be the most widely applied technology due to simplicity of its SCADA system applied in an SBR type reactor, at strictly controlled pH, and high efficiency of nitrogen removal. Low oxygen demand attributed to a short denitrification phase and application of hydrocyclones, resulted in easily and efficient retention of "anammox" bacteria, are clear advantages of the process.

2. WASTEWATER TREATMENT PLANT IN ZABRZE

This plant is situated in the central part of sewer agglomeration of more than 100.000 PE. The inflow wastewater consists of high load of carbon and biogenic substances. On the other hand, the main flow is supplied with the effluents coming from sludge thickening and dewatering. The current hydraulic load is equal to 50% of the designed capacity. Thus, the efficiency of biological removal of nitrogen compounds is strongly reduced.

2.1. Short description of applied technology

The technology is based of multiphase activated sludge process, with a simultaneous removal of organic carbon, nitrogen and phosphorous compounds, well known as a Johannesburg process (JHB) [17]. The current flow capacity is 33 400 m^3/d. The inflowing wastewater flows through preliminary screens and next through three operating simultaneously steps creens and two-chamber aerated sand trapper. In the next phase wastewater is pumped into a primary settling tank where the suspension solids are sedimented and form volatile fatty acids (VFAs) to increase the efficiency of the denitrification process. Then, the flow from the primary settling tank is directed into the biological reactors, through the sequence of chambers, i.e. dephosphatation, denitrification and nitrification. After that wastewater flows into secondary decanters to be clarified and then it is discharged in to the river and partly used as a technological water, taken by a local district heating plant. The sludge formed in the secondary decanters is returned to the pre-denitrification chamber which is located before the dephosphorization chamber. The residual amounts of nitrates are reduced there to increase the efficiency of biological dephosphatation. Moreover, the biological process of phosphorous removal is supported by a chemical precipitation using polyaluminium chloride.

The sludge separated in the primary settling tank is directed to fermenters where VFAs are generated. VFAs, being a rich source of organic carbon, are fed into denitrification chambers. The remaining part of sludge collected in fermenters becomes a part of batch for the closed and heated up fermentation chambers. Excess sludge from secondary decanters is also directed there. A mixture of raw and excess sludge undergoes mesophile fermentation for about 30 days of anaerobic decomposition. The fermented sludge is dehydrated in centrifuges and then

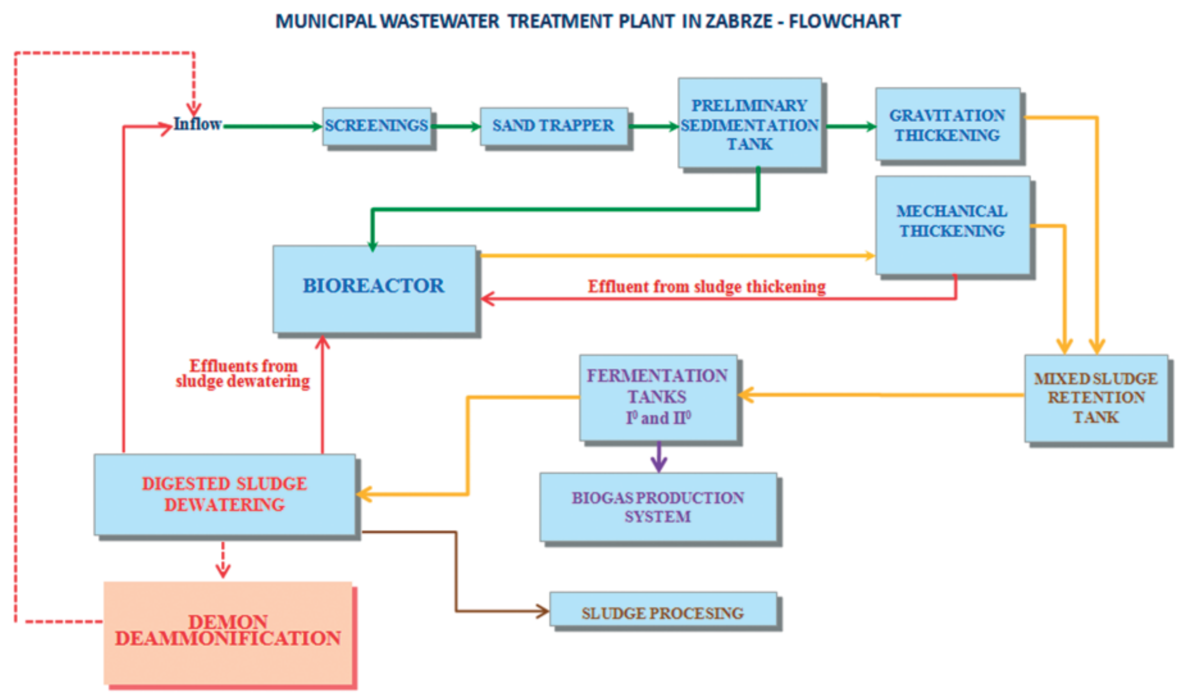

Figure 3.
Municipal "Śródmieście" WWTP in Zabrze – flowchart

processed with addition of lime. The main product of the fermentation process is biogas containing minimum of 62% of methane which is used as fuel in co-generator units. The WWTP in Zabrze illustrated in Figure 3.

2.2. Concentrations and loads of ammonia nitrogen in the years of 2017–2018

Loads and concentrations of ammonium nitrogen in the years of 2017 and 2018 at various technological stages of the process are described in Tables 1 and 2. Ammonium nitrogen concentration in the inflow show typical values for municipal wastewater – at the level of 60 g/m^3. The value is by 8% lower than after

Table 1.
Comparison of N-NH$_4^+$ concentrations at the corresponding points of the technological cycle

	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
	Raw wastewater		Wastewater after sedimentation tank		Treated wastewater		Wastewater after sludge thickener		Effluent after centrifuge	
	Ammonium nitrogen [g N-NH$_4^+$/m^3]									
January	64.1	57.9	62.6	63.0	0.5	0.4	0.8	1.2	1006.0	1368.5
February	44.0	55.1	43.0	53.2	0.5	0.3	0.8	0.8	1079.5	1376.5
March	45.5	64.9	45.0	62.5	0.4	0.8	0.8	0.7	1153.0	1586.0
April	42.0	70.2	43.5	57.6	0.3	0.3	1.0	0.2	1189.5	1596.0
May	41.8	64.6	41.4	43.6	0.4	0.3	1.9	0.9	1093.0	1004.0
June	59.8	60.6	56.6	55.2	0.4	0.3	1.1	0.1	1187.5	988.0
July	59.4	62.7	46.7	58.3	0.3	0.5	1.8	1.2	1016.0	905.5
August	64.9	55.6	70.1	58.3	0.6	0.3	1.5	1.4	1013.0	937.0
September	54.5	68.1	41.5	60.8	0.2	0.3	0.9	0.3	1011.0	934.0
October	50.5	71.1	48.9	41.4	0.2	0.1	0.5	1.5	1054.5	910.0
November	55.8	69.9	48.5	70.1	0.4	0.0	1.2	0.2	1166.5	918.0
December	50.9	69.5	46.8	64.0	0.5	0.2	2.1	1.6	1306.5	602.0
Average	52.8	64.2	49.5	57.3	0.4	0.3	1.1	0.8	1106.3	1093.8
Min.	41.8	55.1	41.4	41.4	0.2	0.0	0.5	0.1	1006.0	602.0
Max	64.9	71.1	70.1	70.1	0.6	0.8	2.1	1.6	1306.5	1596.0

Table 2.
Comparison of $N\text{-}NH_4^+$ loads at the corresponding points of the technological cycle

	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
	Raw wastewater		Wastewater after sedimentation tank		Treated wastewater		Wastewater after sludge thickener		Effluent after centrifuge	
	Ammonium nitrogen [g $N\text{-}NH_4^+$/d]									
January	1086.4	1159.5	1060.1	1262.7	8.1	8.3	20.9	36.9	206.7	265.3
February	861.7	986.7	842.1	951.8	8.8	6.0	15.9	19.5	218.5	246.5
March	1024.2	1156.2	990.4	1113.4	8.7	13.9	16.4	21.5	230.3	279.9
April	1064.7	1294.4	1102.7	1062.1	6.2	4.7	22.0	4.6	190.2	349.5
May	956.7	1251.8	947.5	844.6	9.9	6.5	36.5	25.9	187.2	187.9
June	1172.6	1081.8	1109.9	986.2	8.0	4.9	19.5	3.0	140.2	151.6
July	1104.9	1227.7	867.8	1142.4	4.6	9.8	51.5	32.1	210.8	157.9
August	1175.7	928.1	1269.9	972.5	9.9	4.2	54.7	38.2	230.5	183.3
September	1433.1	1275.1	1089.9	1137.5	5.7	4.8	37.3	8.3	226.3	161.1
October	1219.2	1264.6	1180.6	738.8	5.4	1.4	18.9	50.7	232.7	173.1
November	1264.8	1208.8	1100.3	1211.4	9.8	0.3	47.9	5.1	204.8	176.2
December	1178.7	1433.2	1083.7	1319.7	10.6	4.9	86.4	25.7	226.6	97.19
Average	1128.6	1188.9	1053.6	1061.9	7.9	5.8	35.7	22.6	208.7	202.5
Min.	861.7	928.1	842.1	738.8	4.6	0.3	15.9	3.0	140.2	97.2
Max	1433.1	1433.2	1269.9	1319.7	10.6	13.9	86.4	50.7	232.7	349.5

Table 3.
Efficiency of $N\text{-}NH_4^+$ removals

	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
	Raw wastewater		Effluent after centrifuge		Treated wastewater		% of N- NH_4^+ in total nitrogen		% of N- NH_4^+ reduction	
	Ammonium nitrogen [g $N\text{-}NH_4^+$/d]									
January	1086.4	1159.5	206.7	265.3	8.1	8.3	19.0	22.9	99.3	99.3
February	861.7	986.7	218.5	246.5	8.8	6.0	25.4	24.9	98.9	99.4
March	1024.2	1156.2	230.3	279.9	8.7	13.9	22.5	24.2	99.2	98.8
April	1064.7	1294.4	190.2	349.5	6.2	4.7	17.9	27.0	99.4	99.6
May	956.7	1251.8	187.2	187.9	9.9	6.5	19.6	15.0	98.9	99.5
June	1172.6	1081.8	140.2	151.6	8.0	4.9	11.9	14.0	99.3	99.5
July	1104.9	1227.7	210.8	157.9	4.6	9.8	19.1	12.9	99.6	99.2
August	1175.7	928.1	230.5	183.3	9.9	4.2	19.6	19.8	99.2	99.5
September	1433.1	1275.1	226.3	161.1	5.7	4.8	15.8	12.6	99.6	99.6
October	1219.2	1264.6	232.7	173.1	5.4	1.4	19.1	13.7	99.6	99.9
November	1264.8	1208.8	204.8	176.2	9.7	0.3	16.2	14.6	99.2	99.9
December	1178.7	1433.2	226.6	97.2	10.6	4.9	19.2	6.8	99.1	99.7
Average	1128.6	1188.9	208.7	202.5	7.99	5.8	18.8	17.4	99.3	99.5
Min.	861.7	928.1	140.2	97.2	4.6	0.3	11.9	6.8	98.9	98.8
Max	1433.1	1433.2	232.7	349.3	10.6	13.9	25.4	27.0	99.6	99.9

a preliminary sedimentation tank, as expected. The average annual value of ammonium nitrogen in the out let is at the level of 0.4 g/m^3 to confirm the correct operating results.

It is easy to notice, see the corresponding columns of Table 1 and 2, that ammonium nitrogen concentrations after excessive sludge thickening is almost negligible, whereas ammonium nitrogen concentration in the effluents after digested sludge dewatering shows very high contribution to a total nitrogen load. The detailed numbers for ammonium nitrogen concentrations in the effluents after digested sludge dewatering, to show ca 20% contribution of it in the total wastewater inflow load, are presented in Table 3. Nevertheless, the nitrogen removal efficiency is at a very good level of 99%.

It is worth noticing the high concentrations on average above 1000 gN-NH_4^+/m^3 of nitrogen in the effluents after sludge dewatering. The relationships between nitrogen concentrations in the raw wastewater and in the effluents after dewatering and final efficiency of nitrogen reduction process are shown in Table 3.

3. OPERATING CHALLENGES REFERING TO $N\text{-}NH_4^+$ REMOVAL FROM THE EFFLUENT

According to numerous daily operating reports the observed high concentrations of ammonia nitrogen are a source of many operating troubles. The reason is that the real, current load of ammonia nitrogen is by 20% higher than assumed in the technical design. The main sources of ammonia nitrogen and the methods if its removal are presented below.

3.1. Concentration of ammonia nitrogen in the raw wastewater and its consequences

Water consumption level is well below it was assumed in the technical design calculations. As a consequence, the observed concentrations of all the contaminants, including ammonia nitrogen, are higher than expected (Table 1), what is a source of serious operating problems. One of the methods to improve nitrogen removal biological process is to elongate hydraulic retention time (HRT) in the technological reactors. As a result, a low hydraulic load and a high activated sludge load are observed. As a by-result of this situation, very high age of the sludge (up to 30 days) and the high concentrations of activated sludge, ca. 7–8 g/m^3 at winter time and 5–6 g/m^3 at summer time, are kept in the wastewater treatment plant.

Hence, in order to secure required high amount of suspended biomass and a high level of oxygen for microorganisms, the high energy supply should be provided. The effective denitrification requirement is the other problem to arise there, since the easily available organic carbon is necessary for denitrification bacteria whereas the majority of carbon is removed in the bioreactor, especially in the nitrification chamber. This is the key performance problem in the wastewater treatment plant.

3.2. The influence of centrifuge effluent on the main stream technological processes

As a rule, the inflowing wastewater is treated together with the own technological wastewater in most of the plants. Two main sources of the wastewater are present in the described wastewater treatment plant, i.e. the effluents after excessive sludge thickening and the effluents from the fermented sludge dewatering process 300 to 1200 m^3/day of the excessive sludge is thickened in the former process.

The volumes of effluents and $N\text{-}NH_4^+$ concentrations are, however, at very low levels (Tables 1 and 2) and they do not have any noticeable influence on the main technological process. In the latter process, in contrast, 100 to 350 m^3/day of the sludge is dewatered and $N\text{-}NH_4^+$ concentrations in the effluent are higher than 1000 g/m^3 (Table 1), with a total load of more than 200 kg/day (Table 2), what makes more than 20% of a daily load of raw wastewater. It is a source of many serious operating problems.

3.3. The remedies to improve current situation

Due to sufficient technical and technological flexibility of the process lines, supported by experienced staff, there are several options to improve efficiency of the processes. There are as follows:

- ***Cyclic retention of centrifuges effluents in the retention tank***

  The effluent discharge could be controlled or temporarily stopped, e.g. at the weekends, when sludge dewatering does not occur. As a result, the external pressure on the main technological line is reduced or stopped. The limited volume of the retention tank, up to 24 hours, is a clear disadvantage.

- ***Various ways of effluents addition***

  Depending on technical effectiveness of the available equipment and process lines and in relation to the current properties of activated sludge, it is possible to add the effluents directly to the technological chambers or, via the internal pumping stations system, to the raw wastewater inflow. The method is strongly dependent on the weather conditions (temperature) and it should be forerun by a careful physicochemical analysis of the wastewater and a microscopic analysis of activated sludge

- ***External organic carbon***

  The fermenters, to form easily consumable volatile fatty acids (VFA), are considered as a very important part of the technological process in the examined wastewater treatment plant. The VFA are added to a denitrification chamber 4–5 times a day. If, however, a deficit of organic carbon occurs, the raw wastewater, rich of organic pollutants, is directed to biological reactors, passing over the preliminary settling tank. The denitrification bacteria have therefore an easy access to available organic carbon to enable efficient denitrification. The apparent side-effect is a large increase of activated sludge volume and the worse properties of the sludge to be fermented. It is a clear effect of the passing over the preliminary settling tank, resulted in a 50% reduction of preliminary sludge inflow into the fermenter. Thus, the fermentation components are not in the favourable relations. Moreover, the structure of activated sludge is also changed to produce less biogas and to make dewatering process more difficult and required a different polyelectrolyte.

4. DEMON® – A NOVEL ROUTE TO REMOVE $N\text{-}NH_4^+$

The most popular commercial system for deammonification is the DEMON® technology which is based on suspended biomass of bacteria anammox in the form of small granules and in flocculent biomass of activated sludge [12, 13, 15]. DEMON®process is a specific modification of a SHARON-ANAMMOX® technology and it refers do nitrogen removal by means of a combined partial nitrification and Anammox® technology carried out in a SBR reactor, at strictly controlled pH values. The bacteria to oxidize ammonia nitrogen into nitrates(III) coexist together with "anammox" bacteria in the reactor. The key parameters of a DEMON® process are pH and oxygen concentration – aeration time depends on pH changes. The key feature is that ammonia nitrogen oxidation into nitrates(III) is followed by pH decrease, whereas in the aerobic oxidation of ammonia by "anammox" bacteria, pH increase is observed. Therefore the aeration system is activated at the higher values of pH and it is stopped at the lower pH values. It is worth adding that the gap between these two bounding values is not too big. Thus, a complete treatment cycle in the SBR reactor consists of many partial cycles of aeration and mixing in a DEMON® process. The cycle is finished by a sludge sedimentation. The aeration conditions, i.e. oxygen concentration of 0.3–0.5 g/m^3, are sufficient to prevent nitrates(III) oxidation into nitrates(V). On the other hand, a low oxygen concentration is followed by reduction of nitrates(III) oxidation bacteria growth, to facilitate their "leaching" out of the reactor. Due to a very low rate of "anammox" bacteria growth, the DEMON® system is operating at a long sludge age, ca.20 days.

The separators, e.g. cyclones, are applied to separate the "anammox" bacteria out of the excessive sludge and to recycle them into the Demon reactor. Hence, the DEMON® technology is strongly recommended to a wide application. This technology (Fig. 3) [15] is based on a short nitrification and deammonification processes performed in the SBR reactor. The process is characterized by a very small growth of activated sludge (flocs-like type) because of a low oxygen concentration. It contributes, therefore, to the limited dimensions of the reactor. Moreover, a cyclone application, to keep deammonification bacteria in the reactor, is a solution for their low concentration in the reactor. The short nitrification process is con-

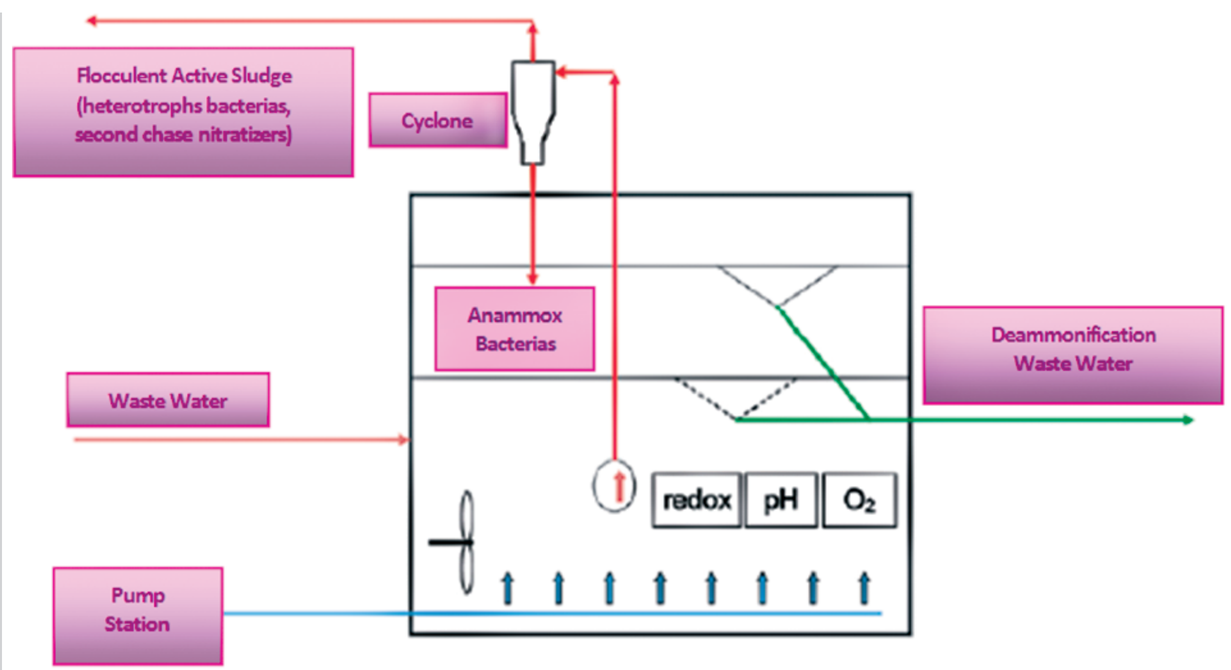

Figure 4.
The principles of a DEMON® reactor activity [15]

trolled by a precise pH measurement connected with aeration system. Nitrogen removal efficiency is ca. 85–90% in the DEMON® reactor [15].

There are some other clear advantages of this technology, i.e. it is not necessary to apply external sources of organic carbon, even though there is a low concentration of organic carbon in the effluent (note, that deammonification bacteria are the autotrophs) and the process requires by 60% less energy in comparison to a classic nitrification-denitrification process.

The mentioned above reasons encouraged us to apply DEMON® technology in the "Śródmieście" WWTP in Zabrze. It was applied in a side technological line. The preliminary calculations, based on the real nitrogen concentrations in the effluents, are described in the next chapter.

5. PRELIMINARY CALCULATIONS OF A DEMON® REACTOR

5.1. The reactor's capacity

The average flow of the fermentation effluents (reject water) from the centrifuges is Q_{eff}=190 m^3/day and a value of 200 m^3/day was assumed in the following calculations. The average concentration of ammonium nitrogen is 1100 g/m^3. Thus, a calculated load is:

$$L_{N\text{-}NH4+} = 200\ m^3/d \times 1100\ g\ N\text{-}NH_4^+/m^3 = 220\ kg\ N\text{-}NH_4^+/d$$

The $N\text{-}NH_4^+$reactor load is usually assumed as:

$A_{unit.}$ = 0.5–0.7 kg $N\text{-}NH_4^+/m^3d$ and in our case it was assumed as equal to 0.63 kg/m^3·d.

Thus, the required effective reactor volume is:

$$V_R = L_{N\text{-}NH4+}/A_{unit} = 220 / 0.63 = 350\ m^3$$

where: V_R – effective reactor volume (m^3),

$L_{N\text{-}NH4+}$ – nitrogen load (kg $N\text{-}NH_4^+$/d),

A_{unit}. – reactor nitrogen load (kg $N\text{-}NH_4^+/m^3d$)

5.2. Oxygen demand

- Unit oxygen demand: $OC_{unit.}$ = 1.7 kg O_2/kg N
- 24 hours oxygen demand: $OC_d = Q\ N\text{-}NH_4^+ \times OC_{unit.} = 220 \times 1.7 = 374$ kg O_2/d
- Aeration time: T = 15 h/d
- Hourly oxygen demand: $OC_h = OC_d/15 = 25$ kg O_2/h

where:

$OC_{unit.}$ – unit oxygen demand (kg O_2/kg $N\text{-}NH_4^+$),

OC_d – 24 hours oxygen demand (kg O_2/d),

OC_h – hourly oxygen demand (kg O_2/h).

5.3. Basic reactor equipment

The reactor is composed of:

- submersible mixer,
- movable decanter bed,
- hydrocyclone,
- pomp to feed hydrocyclone,
- fine bubble aeration grid,
- measuring equipment: pH, conductivity, oxygen, temperature, reactor filling level.

6. CONCLUSION

According to the current legal regulations, the analyzed WWTP is entitled to discharge wastewater with maximum concentration of total nitrogen equal 10 mg/dm^3, as attributed to the value of more than 100.000 PE. The effective removal of nitrogen load, including the additional ammonium nitrogen load, coming from effluents after dewatering of fermented wastewater sludge, still remains a challenge. The effluents coming from sludge dewatering contain ammonia nitrogen at the concentration of ten time higher than these in the raw wastewater. This causes a significant organic carbon deficit in denitrification chambers in the mainstream process line. Organic carbon is necessary for denitrifying bacteria for effective reduction of nitrates(V). Generally, two options could be taken into account to solve this problem i.e. use of external source of organic carbon or construction of deammonification installation at the side technological stream.

The considerations presented in this publication lead to the conclusion that the application of the innovative technology of deammonification (in sidestream) to effective removal of nitrogen seems to be the best option in most of wastewater treatment plants.

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