

REMOVAL OF AMMONIA AND PHENOL FROM INDUSTRIAL WASTE WATER

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ABSTRACT

The activated sludge process is a wastewater treatment method in which the carbonaceous organic matter of wastewater provides an energy source for the microorganisms. The microbes convert carbon into cell tissue and oxidized end products that include production of new cells for a mixed population of microorganisms in an aquatic aerobic environment carbon dioxide and water. In addition, a limited number of microorganisms may exist in activated sludge that obtains energy by oxidizing ammonia nitrogen to nitrate nitrogen in the process known as nitrification.

The beneficial role of nitrifying bacteria within saltwater and freshwater aquaria environments is their function in the nitrogen cycle, which involves the conversion of ammonia to nitrite and the subsequent conversion of nitrite to nitrate. During the process of nitrification, nitrifying bacteria detoxify ammonia in two steps. First, Nitrosamines spp. converts toxic ammonia to nitrite, which is also toxic to fish. Then in the second step, nitrite is converted to nitrate by the Nitrobacter spp. Nitrate is not considered toxic unless it accumulates in high concentrations.

There are numerous commercial products claiming to contain nitrifying bacteria that will facilitate the conversion of toxic ammonia to non-toxic nitrate within aquaria.

In this paper we discussed the factors affecting on the growth of nitrifying bacteria and the best conditions to reduce (over 85% of ammonia, over 90% of phenol and over 80% of BOD) in biological step in waste water treatment plant for industrial waste water.

INTRODUCTION

The beneficial role of nitrifying bacteria within saltwater and freshwater aquaria environments is their function in the nitrogen cycle, which involves the conversion of ammonia to nitrite and the subsequent conversion of nitrite to nitrate. During the process of nitrification, nitrifying bacteria detoxify ammonia in two steps. First,

Nitrosomonas spp. converts toxic ammonia to nitrite. Then in the second step, nitrite is converted to nitrate by the *Nitrobacter* spp.

Nitrate is not considered toxic unless it accumulates in high concentrations. There are numerous commercial products claiming to contain nitrifying bacteria that will facilitate the conversion of toxic ammonia to non-toxic nitrate within aquaria.

This study was undertaken to investigate the efficacy of both nitrification and de-nitrification. Efficacy was determined by measuring the conversion of ammonia and nitrate for nitrification and by measuring the reduction of BOD and phenol for de-nitrification.

Studies in our laboratory have indicated that the factors affecting on nitrification and de-nitrification processes.

BIOLOGICAL TREATMENT

The biological treatment consists of two steps nitrification and de-nitrification in the most plants the first step is nitrification and the second step is the de-nitrification but in our plant the first step is de-nitrification and the second step is the nitrification. One study demonstrated that a C: N ratio of at least 3:1 was necessary after nitrification to promote de-nitrification. At lower C: N ratios, the rate of de-nitrification decreased rapidly. One preferred method to avert the problem of effluent degradation is to place the de-nitrification basin before the aerobic reactor basin (in which carbonaceous removal and nitrification are taking place) and recycle a high volume of the flow from the nitrification reactor basin back to the de-nitrification basin. Raw wastewater also has been used as the source of organic carbon to effect de-nitrification. However, this procedure may adversely affect effluent quality by causing increases in BOD₅ and ammonia.

BIOLOGICAL FLOCCULATION

One of the factors essential to the performances of the activated sludge process is effective flocculation of the sludge, with subsequent rapid settling and compaction of the floc, it has been shown that flocculation results from the production of a sticky polysaccharide slime layer to which organism adhere. Flagellates are also entrapped in this slimy material. The slime formation does not occur during the long-growth phase and required excess available carbohydrate. Effective flocculation therefore requires a relatively low food-to microorganism's ratio (declining growth and high sludge age) and excess available carbohydrate. Flocculation itself will not ensure rapid settling. Conditions in the process must be maintained to promote a high-density sludge.

In general, the maintenance of aerobic conditions with an available carbon source stimulates the growth of fungi and other filamentous forms, resulting in so-called bulking sludge.

Okun indicated that Spherotilus are aerobic and require oxygen and an available carbon source but may suffer in the competition for food in highly aerobic environment. Because of their high surface area/volume ratio, the filamentous organisms may survive better under low oxygen tensions than other flocculated aerobic growth. Failure to maintain oxygen in the aeration system can result in diffuse non settling flocs because of the high for production under anaerobic conditions.

Maintenance of aerobic conditions in the aeration tank, followed by an anaerobic period in the final clarifier, appears to promote growth of facultative bacteria which are effective in the removal of BOD and produce high-density flocs and to limit the growth of filamentous organisms.

NUTRIENT REQUIREMENTS

In all biological waste treatment systems it is necessary for microorganism to have all the necessary elements to build protoplasm. The nutritional requirements of microorganism fall into four categories:

- Compounds that furnish carbon and nitrogen.
- Compounds that serve as a sources of energy.
- Inorganic ions.
- Trace substances.

All natural organic substances, some inorganic, and many synthetic ones are attached by at least one species of microorganism. Some organic substances as their primary food source while others are more specific. All microorganisms require the basic elements:

- carbon, nitrogen, phosphorus, and sulfur together

With certain trace elements such as:

- Potassium, calcium, zinc, magnesium, iron, manganese, copper, and cobalt.

Carbon, nitrogen, and phosphorus generally are required in balanced amounts.

Most of the compounds entering into the growth of active biomasses are normally available in the treatment plant influent.

As a result domestic wastewater generally provides a nutritionally balanced food source for bacterial activity. However, the presence of a large proportion of certain industrial wastes, devoid in nitrogen or phosphorus, may upset this balance. In such cases nutrient addition may be necessary.

One of the most important aspects of nutritionally deficient wastes is their effect on biological predomination. A partially deficient nitrogen or phosphorus waste will stimulate fungal rather than bacterial growth since the fungi build protoplasm with

lower nitrogen and phosphorus contents. The fungi that predominate are filamentous and may cause bulking of activated sludge in secondary sedimentation tanks.

When insufficient nitrogen is present, the amount of cellular material synthesized per unit of organic matter removed increases as an accumulation of polysaccharide. At some point nitrogen limiting conditions restrict the rate of BOD removal. Not all organic nitrogen compounds are available for synthetics. Ammonia is the most readily available form, and other nitrogen compounds must be converted to ammonia. Nitrite, nitrate and about 75% of organic nitrogen compounds are also available.

How much nitrogen and phosphorus are required to promote active biomass generation?

- A chemical analysis of a mixed aerobic bacterial population in biological waste treatment gave an approximate composition of cell tissue as $C_5H_7O_2NP_{0.2}$. On this basis, 11.8 and 5.2 % by weight of nitrogen and phosphorus, respectively, would be required to promote bacterial cell development. The weight of each element required per day then would be determined by multiplying these percentage factors by the weight of organisms produced per day.
- The more conservative approach for estimating nitrogen and phosphorus requirements in biological treatment systems relates the influent BOD_5 to the quantity of these elements required as 20:1 for BOD_5 : N and 100:1 for BOD_5 : P. These ratios can be used on either a mass or concentration basis.

Sources of nitrogen

- Bacteria derive their source of elemental nitrogen by assimilating ammonia, but also have the ability to use nitrites and nitrates as well as gaseous nitrogen under certain circumstances. Most facultative bacteria of importance in activated sludge systems have the ability to reduce nitrates to nitrites and, through a series of intermediates, to ammonia for incorporation into protoplasm. This assimilative reduction of nitrates and nitrites is specific for meeting their protoplasmic needs and can occur in the presence of excess oxygen but will not occur as long as there is an excess of ammonia.
- Bacteria derive their source of elemental nitrogen by assimilating urea.

Sources of phosphorus

- Bacteria derive their source of elemental phosphorus by assimilating soluble orthophosphate $(PO_4)^{-8}$. This ion is the final breakdown product in the phosphorus cycle and is the form in which phosphorus is most readily available for biological use.

- Inorganic polyphosphates also can serve as a source of elemental phosphorus because, in aqueous solutions, they hydrolyze and revert to the ortho form from which they were derived. This rate of reversion is increased by an increase in temperature and a lowering of pH of the aqueous solution. Complex organic phosphates hydrolyze very slowly and are not recommended for use as a source of elemental phosphorus.

DE-NITRIFICATION

De-nitrification is the process of reducing nitrate a form of nitrogen available for consumption by many groups of organisms, into gaseous nitrogen which is far less accessible to life forms but makes up the bulk of our atmosphere. It can be thought of as the opposite of nitrogen fixation, which converts gaseous nitrogen into more biologically useful forms. The process is performed by heterotrophic bacteria (such as *Pseudomonas fluorescens*) from all main proteolyses groups. De-nitrification takes place under special conditions in both terrestrial and marine ecosystems. In general, it occurs when oxygen (which is a more favorable electron acceptor) is depleted, and bacteria turn to nitrate in order to breathe organic matter. De-nitrification proceeds through some combination of the following steps:

Nitrate → nitrite → nitric oxide → nitrous oxide → di-nitrogen gas or expressed as a redox reaction:



De-nitrification in a water-sediment system is affected by:

- Temperature
- Dissolved oxygen
- nitrate concentrations in the water overlying the sediment

PSEUDOMONAS

Pseudomonas bacteria are aerobic Gram- negative bacilli; motile with polar flagella, mono- or multi- trichous; oxidase positive and catalase positive typically the breakdown of carbohydrates is oxidative many species produce characteristic water-soluble pigments.

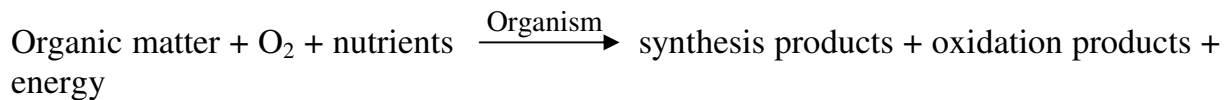
THE MECHANISM OF BOD REMOVAL

When organic is removed from solution by microorganism, two basic phenomena occur:

- Oxygen is consumed by the organism for energy,
- New cell mass is synthesized.

The organism also undergoes progressive auto-oxidation of their cellular mass.

These reactions can be illustrated by the following general equations:



The energy produced is used cell synthesis and maintenance. In endogenous respiration, the bacteria use other bacteria or stored cellular material as a food source.

The bulk of the dissolved organic matter, however, is progressively removed during aeration according to first reaction as sludge is synthesized.

The rate of BOD removal after initial absorption depends upon:

- The concentration of BOD
- The concentration of biological sludge
- The temperature.

BOD removal from a waste by a biological sludge may be considered as occurring in two phases:

- An initial high removal of suspended, colloidal and soluble BOD₅
- A slow progressive removal of soluble BOD₅.

Initial BOD₅ removal is accomplished by one or more mechanisms, depending on the physical and chemical characteristics of the organic matter. These mechanisms are:

- Removal of suspended matter by their enmeshment in the biological flow. This removal is rapid and is dependent upon adequate mixing of the waste with sludge.
- Removal of colloidal material by physiochemical adsorption on the biological floc.
- A bio-adsorption of soluble organic matter by the microorganisms.

There is some doubt whether this removal is the result of enzymatic complexation or is a surface phenomenon and whether the organic matter is held to the material surface or is within the cell as a storage product or both.

The amount of immediate removal of soluble BOD₅ is directly proportional to:

- The concentration of sludge present,
- The sludge age,
- The chemical characteristics of the soluble organic matter.

These three reactions occur immediately on contact of sludge with waste. The colloidal and suspended material must undergo sequential breakdown to smaller molecules in order that it may be made available to the cell for synthesis.

The time required for this in an acclimated system is related primarily to:

- The characteristics of the organic matter
- The concentration of active sludge.

This material is then used by the cell for synthesis in a complex waste mixture at high concentrations of BOD₅. The rate of synthesis is independent of concentration; as a result, there is constant and maximum rate of cellular growth. With continuing aeration the more readily removable components are depleted and the rate of growth will decrease with decreasing concentration of BOD₅ remaining in solution.

When the rate of removal begins to decrease, the sludge still contains unassimilated organic carbon. While removal is progressively decreasing in time beyond this point, synthesis will continue at a maximum rate until the excess carbon concentration in the cell is depleted by conversion into cellular mass. This causes a rapid decrease in cellular mass and cellular carbon accompanied by a corresponding increase in cellular nitrogen,

NITRIFICATION

Nitrification is the biological oxidation of ammonia with oxygen into nitrite followed by the oxidation of these nitrites into nitrates. Nitrification is an important step in the nitrogen cycle.

The oxidation of ammonia into nitrite, and the subsequent oxidation to nitrate is performed by two different bacteria.

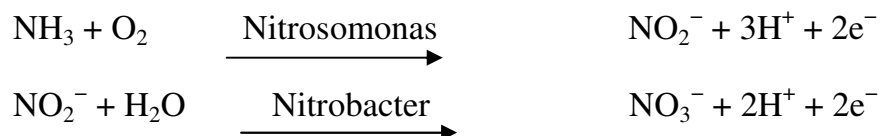
- The first step is done by bacteria of (amongst others) the genus *Nitrosomonas*.
- The second step (oxidation of nitrite into nitrate) is (mainly) done by bacteria of the genus *Nitrobacter*.

All organisms are autotrophs, which means that they take carbon dioxide as their carbon source for growth. Nitrification also plays an important role in the removal of nitrogen from industrial wastewater.

The conventional removal is nitrification, followed by denitrification. The cost of this process resides mainly in aeration (bringing oxygen in the reactor) and the addition of an extra organic energy source (e.g. methanol) for the denitrification.

In most environments both organisms are found together, yielding nitrate as the final product. It is possible however to design systems in which selectively nitrite is formed

Nitrification is a process of nitrogen compound reduction:



Maintaining nitrification would be relatively simple for wastewater treatment plants if they operated in a 'steady state'. However, the desired 'steady state' conditions do not exist in the WWTP environment. For example, all treatment plants experience

significant changes in daily flow, organic loading, nitrogen loading, temperature, and concentrations of toxic chemicals. The nitrification process can be easily upset and lose efficiency with the numerous changes that occur on a daily basis. Of course, the most severe cases occur when a facility violates its ammonia discharge limit. These upsets may last only a short while (a few days or weeks) or can be chronic problems.

In other cases, a plant may nitrify only some of the time, incompletely, or not at all. Many factors may be involved when nitrification is inadequate. Among the most important are:

- Inadequate physical plant design for effective nitrification.
- Inappropriate biological conditions.
- Occasional process upset due to toxic chemical shock.
- Occasional process upset due to hydraulic shock.

NITRIFYING BACTERIA

Nitrifying bacteria are classified as obligate chemolithotrophs. This simply means that they must use inorganic salts as an energy source and generally cannot utilize organic materials. They must oxidize ammonia and nitrites for their energy needs and fix inorganic carbon dioxide (CO₂) to fulfill their carbon requirements. They are largely non-motile and must colonize a surface (gravel, sand, synthetic bio-media, etc.) for optimum growth. They secrete a sticky slime matrix which they use to attach themselves. Species of *Nitrosomonas* and *Nitrobacter* are gram negative, mostly rod-shaped, microbes ranging between 0.6-4.0 microns in length. They are obligate aerobes and cannot multiply or convert ammonia or nitrites in the absence of oxygen.

Nitrifying bacteria have long generation times due to the low energy yield from their oxidation reactions. Since little energy is produced from these reactions they have evolved to become extremely efficient at converting ammonia and nitrite. Scientific studies have shown that *Nitrosomonas* bacterium are so efficient that a single cell can convert ammonia at a rate that would require up to one million heterotrophy to accomplish. Most of their energy production (80%) is devoted to fixing CO₂ via the Calvin cycle and little energy remains for growth and reproduction. As a consequence, they have a very slow reproductive rate.

Nitrifying bacteria reproduce by binary division. Under optimal conditions, *Nitrosomonas* may double every 7 hours and *Nitrobacter* every 13 hours. More realistically, they will double every 15-20 hours. This is an extremely long time considering that heterotrophic bacteria can double in as short a time as 20 minutes. In the time that it takes a single *Nitrosomonas* cell to double in population, a single *E. coli* bacterium would have produced a population exceeding 35 trillion cells. None of the *Nitrobacteraceae* is able to form spores. They have a complex cytomembrane (cell wall) that is surrounded by a slime matrix. All species have limited tolerance ranges and are individually sensitive to pH, dissolved oxygen levels, salt, temperature, and inhibitory chemicals. Unlike species of heterotrophic bacteria, they cannot survive any

drying process without killing the organism. In water, they can survive short periods of adverse conditions by utilizing stored materials within the cell. When these materials are depleted, the bacteria die.

FACTORS AFFECTING ON THE EFFICIENCY OF NITRIFYING BACTERIA

Various parameters play a key role in successful nitrification among these are the following:

- **Temperature**

The temperature for optimum growth of nitrifying bacteria is between 25-30°C.

Growth rate is decreased by 50 % at 18 °C.

Growth rate is decreased by 75 % at 46-50° F.

No activity will occur at 4°C.

Nitrifying bacteria will die at 0°C.

Nitrifying bacteria will die at 49°C.

Nitrobacter is less tolerant of low temperatures than Nitrosomonas. In cold water systems, care must be taken to monitor the accumulation of nitrites

- **pH**

The optimum pH range for Nitrosomonas is between 7.8---8.0.

The optimum pH range for Nitrobacter is between 7.3---7.5

Nitrification works best when the pH is between 6.5 and 8.5. The process slows considerably at pH values outside this range

- **Dissolved Oxygen DO**

Maximum nitrification rates will exist if dissolved oxygen levels exceed 80% saturation. Nitrification will not occur if dissolved oxygen concentrations drop to 2.0 mg/l (ppm) or less. Nitrobacter is more strongly affected by low dissolved oxygen than Nitrosomonas

- **Simultaneous Removal of BOD**

From a practical point of view, nitrification proceeds better when the concentration of soluble BOD is low (less than 20 mg/l). Therefore, many treatment plants are designed with two stages. The first stage is for BOD removal. The second stage is for nitrification. The BOD removal efficiency of a plant is always an important factor in nitrification efficiency.

- **Chemical Inhibition of Nitrifying Bacteria**

There are only two main species of nitrifying bacteria. Nitrosomonas and Nitrobacter. There are varieties of chemicals that are known to inhibit these bacteria, such as sulfides and cyanides (among many others). Since there are only two main species involved, nitrifying bacteria are very susceptible to chemically-based toxicity, shock or upset. Many wastewater treatment plants are subject to discharge permits, which limit the amount of ammonia that can be lawfully discharged. Government permits and regulations influence levels of ammonia and nitrite that may be discharged into streams. The discharge of ammonia or nitrite into a stream, lake or river may cause oxygen to be

consumed, thereby lowering the dissolved oxygen concentration and endangering the aquatic ecosystem.

The result of the different samples will be described as the following tables and figures

MATERIAL AND METHODS:

In this study we used some standard methods to monitor our result as the following:

- ASTM – D 1293 for measuring pH
- ASTM – D 1426 for measuring ammonia
- ASTM – D 888 for measuring dissolving oxygen
- APHA N-4500 for measuring nitrite
- APHA N-4500 for measuring nitrate
- APHA 5210 for measuring BOD
- APHA 9221 for total bacteria count
- APHA 5530 for measuring phenol

RESULTS

Fig:1 Low efficiency of removal of ammonia related to low concentration of dissolved oxygen < 2 mg/l

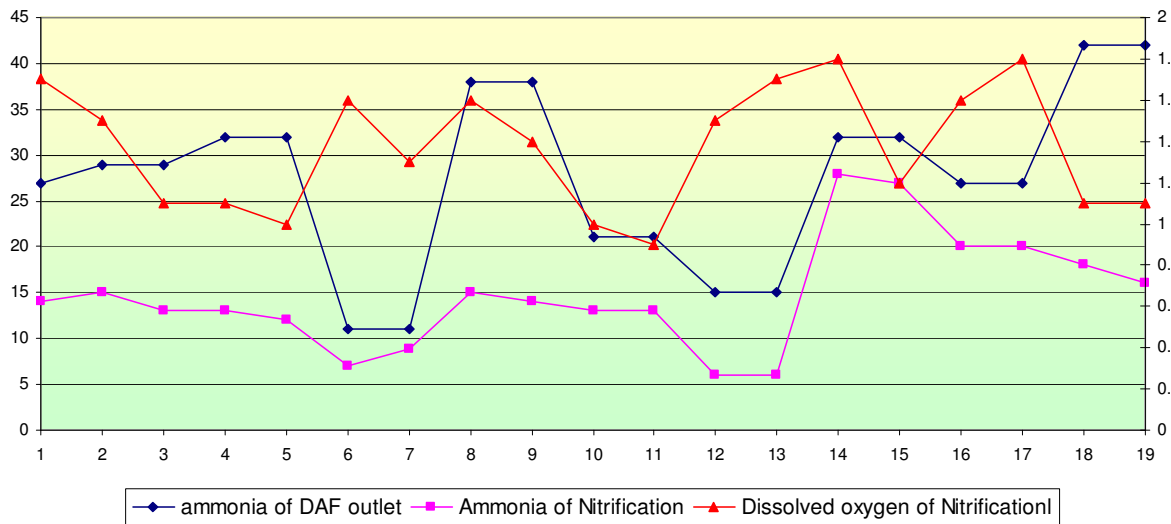


Table 1. Low efficiency of removal of ammonia related to low concentration of Dissolved oxygen < 2 mg/l

Ammonia (ppm) of DAF outlet	Ammonia (ppm) in Nitrification	DO2 (ppm) in Nitrification
27	14	1.7
29	15	1.5
29	13	1.1
32	13	1.1
32	12	1
11	7	1.6
11	8.9	1.3
38	15	1.6
38	14	1.4
21	13	1
21	13	0.9
15	6	1.5
15	6	1.7
32	28	1.8
32	27	1.2
27	20	1.6
27	20	1.8
42	18	1.1
42	16	1.1

Fig:2 High efficiency of removal of ammonia related to concentration of DO₂ >2 mg/l

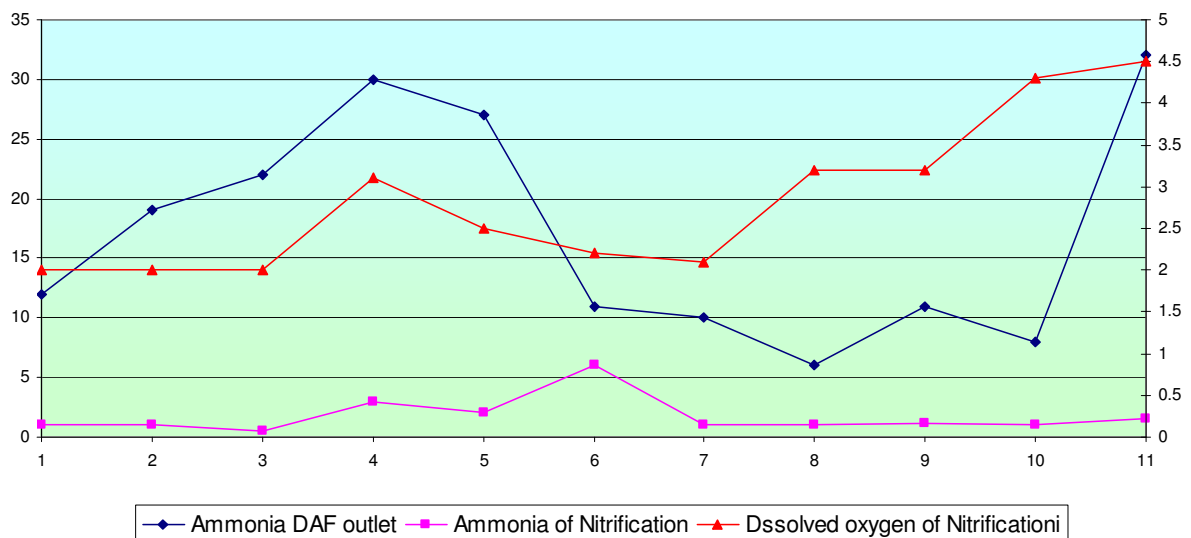


Table 2. High efficiency of removal of NH₃ related to concentration of DO₂ > 2 mg/l

Ammonia (ppm) of DAF outlet	Ammonia (ppm) in Nitrification	DO (ppm) in Nitrification
12	1	2
19	1	2
22	5	2
30	3	3.1
27	2	2.5
11	6	2.2
10	1	2.1
6	1	3.2
11	1.1	3.2
8	1	4.3
32	1.6	4.5

Fig:3 Direct relation between BOD and Ammonia

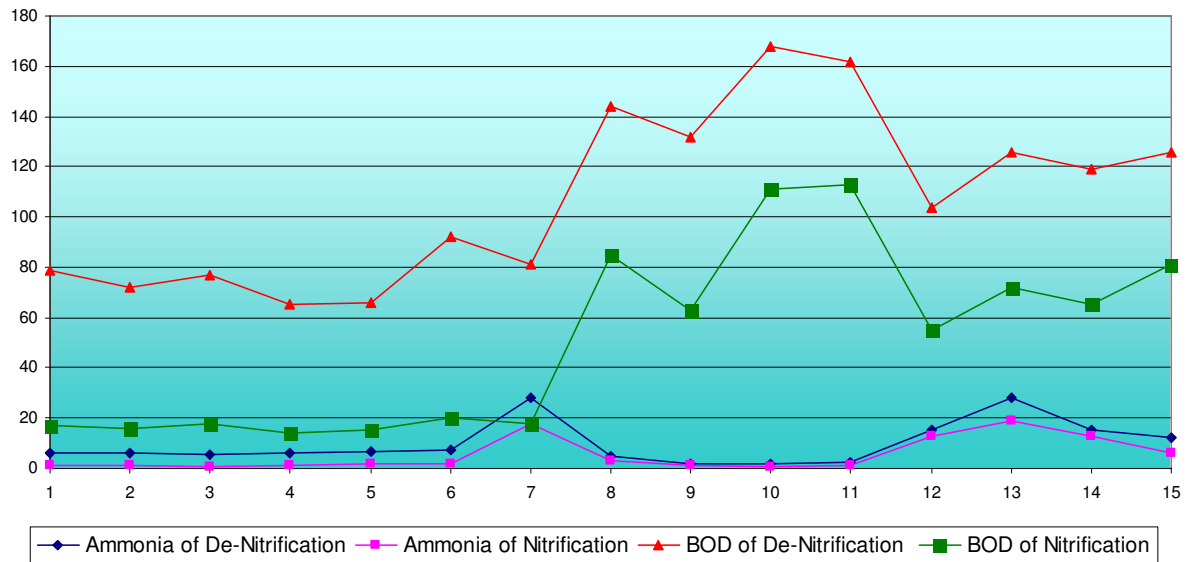


Table 3. Relation between BOD and ammonia

Ammonia of De-nitrification	Ammonia of nitrification	BOD of De-Nitrification	BOD of Nitrification
6.2	1	79	17
5.8	1.1	72	16
5.7	0.9	77	18
6.3	1.5	65	14
6.8	1.8	66	15
7.6	2	92	20
28	18	81	18
5	3	144	85
2	1	132	63
2	0.8	168	111
2.5	1.1	162	113
15	13	104	55
28	19	126	72
15	13	119	65
12	6	126	81

Fig:4 High efficiency of ammonia in biological

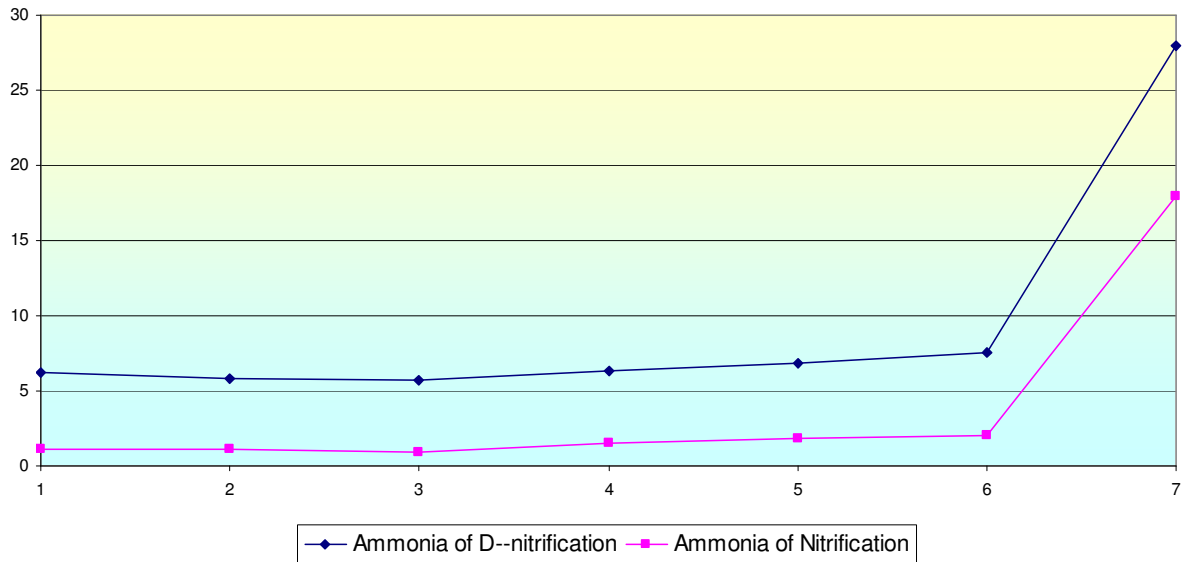


Table 4. High efficiency of ammonia ppm removal in biological

Ammonia of De-nitrification	Ammonia of nitrification
6.2	1
5.8	1.1
5.7	0.9
6.3	1.5
6.8	1.8
7.6	2
28	18

Fig:5 Low efficiency of ammonia in biological

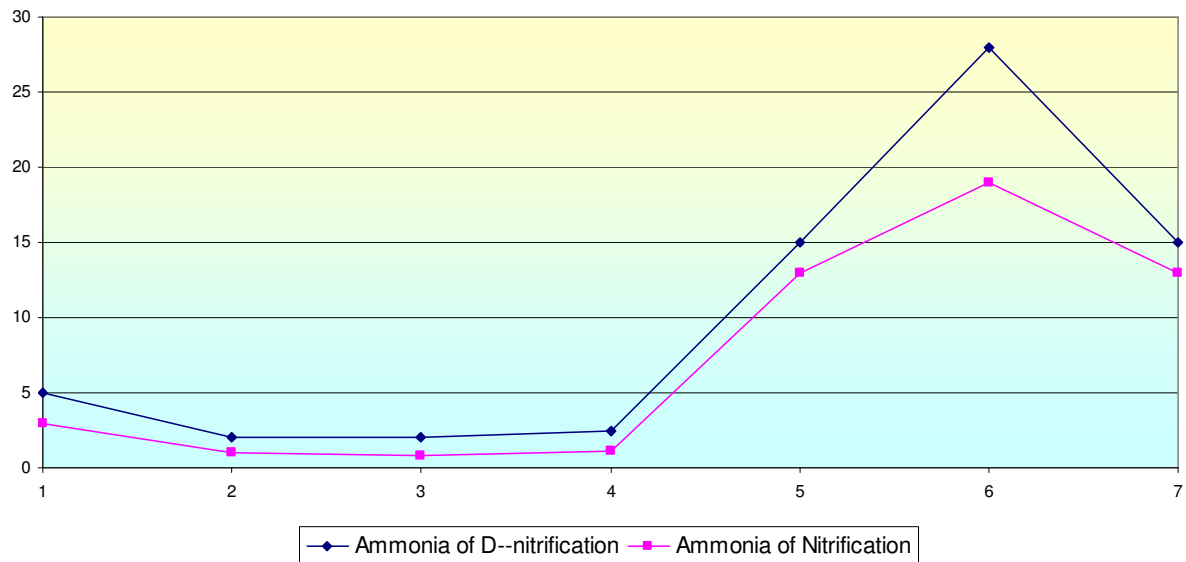


Table 5. Low efficiency of Ammonia ppm removal in biological

5	3
2	1
2	0.8
2.5	1.1
15	13
28	19
15	13

Fig:6 Low efficiency of BOD in biological

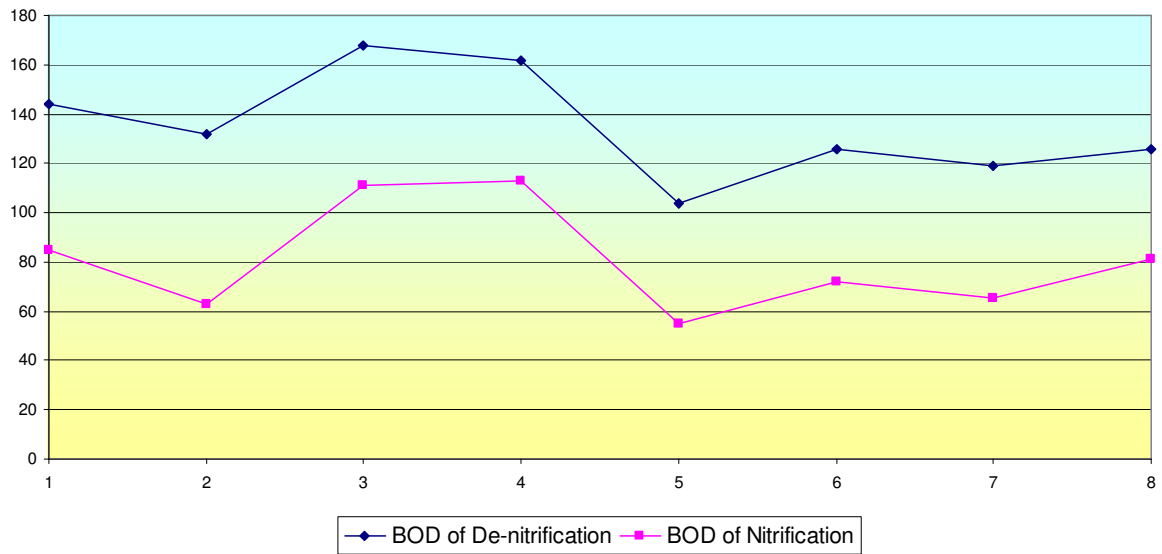


Table 6. Efficiency of BOD ppm removal in biological

144	85
132	63
168	111
162	113
104	55
126	72
119	65
126	81

Fig:7 High efficiency of BOD in biological

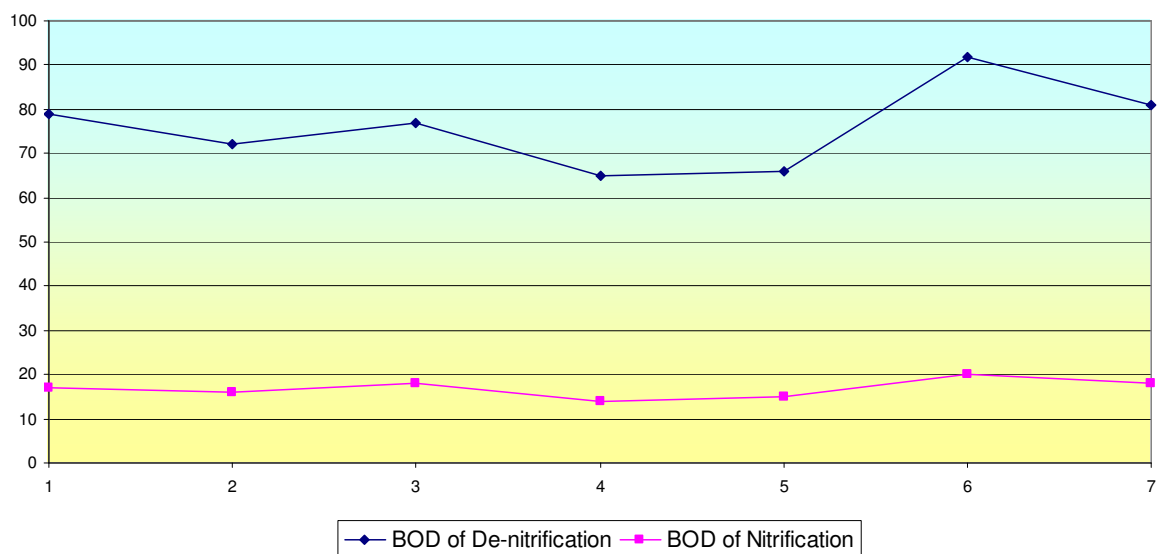


Table 7. Efficiency of BOD ppm removal in biological

BOD of De-Nitrification	BOD of Nitrification
79	17
72	16
77	18
65	14
66	15
92	20
81	18

Fig:8 Efficiency of bacteria with ratio 6:100:30 (P:BOD:N) used DAF outlet

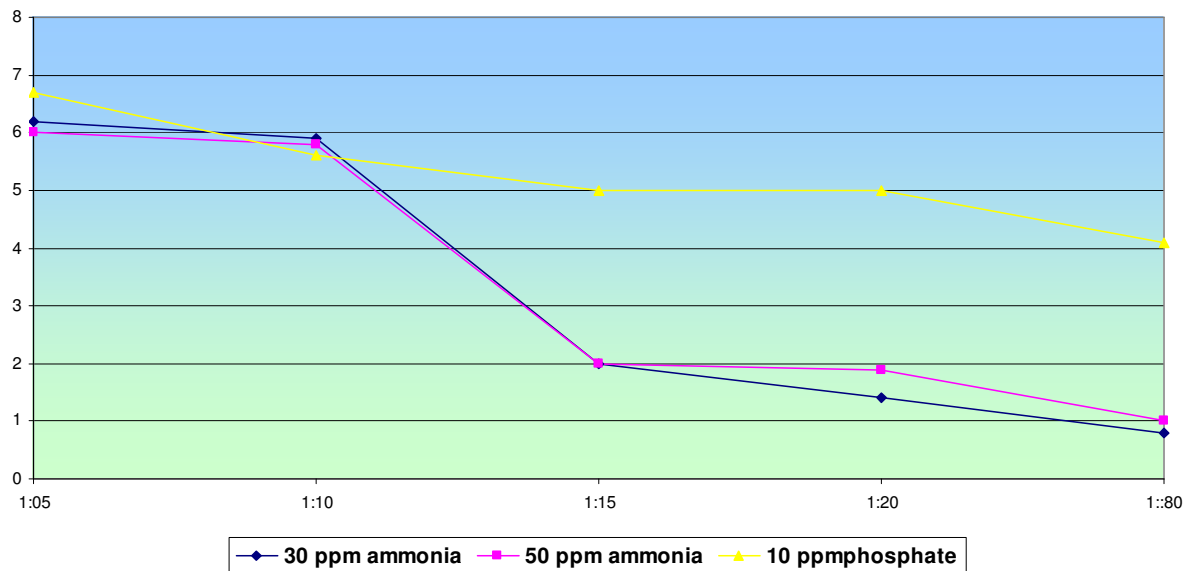


Table 8. Efficiency of bacteria

The ratio 6:100:30 (P:BOD:N)			
Dilution ratio	Dilution used DAF outlet		
	NH4		PO4
1 Nitrobacter	30 ppm	50 ppm	10 ppm
5,10,15 20,80 Nitrosomonas			
1/5	6.2	6	6.7
1/10	5.9	5.8	5.6
1/15	2	2	5
1/20	1.4	1.9	5
1/80	0.8	1	4.1

Fig:9 Efficiency of bacteria with ratio 6:100:30 (P:BOD:N) used demi. water

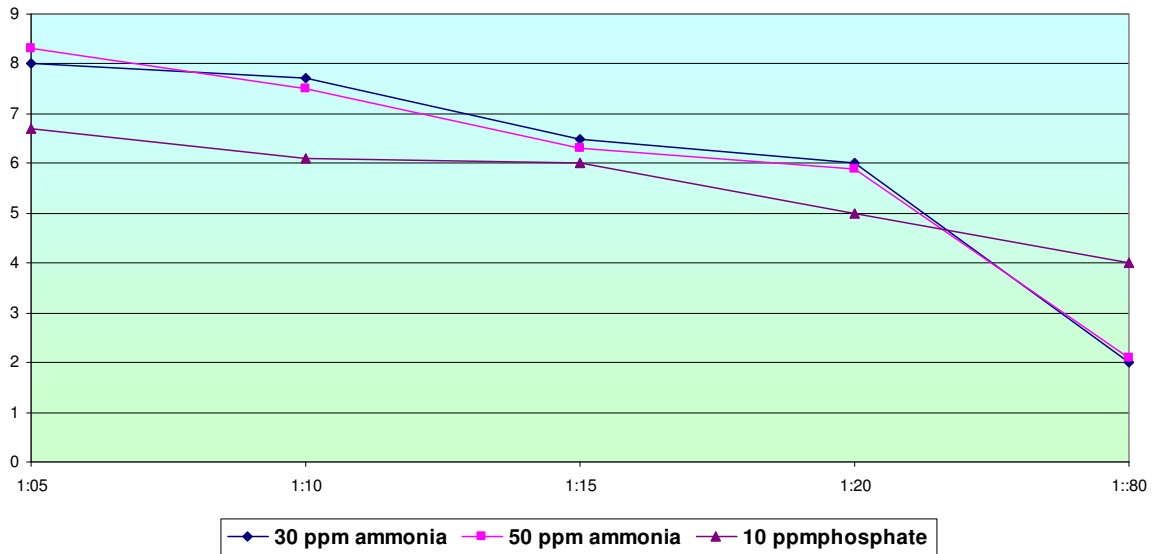


Table 9. Efficiency of bacteria

The ratio 6:100:30 (P:BOD:N)			
Dilution ratio	Dilution used Demi. Water		
1 Nitrobacter	NH4		PO4
5,10,15 20,80 Nitrosomonas	30 ppm	50 ppm	10 ppm
1/5	8	8.3	6.4
1/10	7.7	7.5	6.1
1/15	6.5	6.3	6
1/20	6	5.9	5
1/80	2	2.1	4

Fig: 10 Efficiency of bacteria with different temperture with ratio 6:100:30 (P:BOD:N)

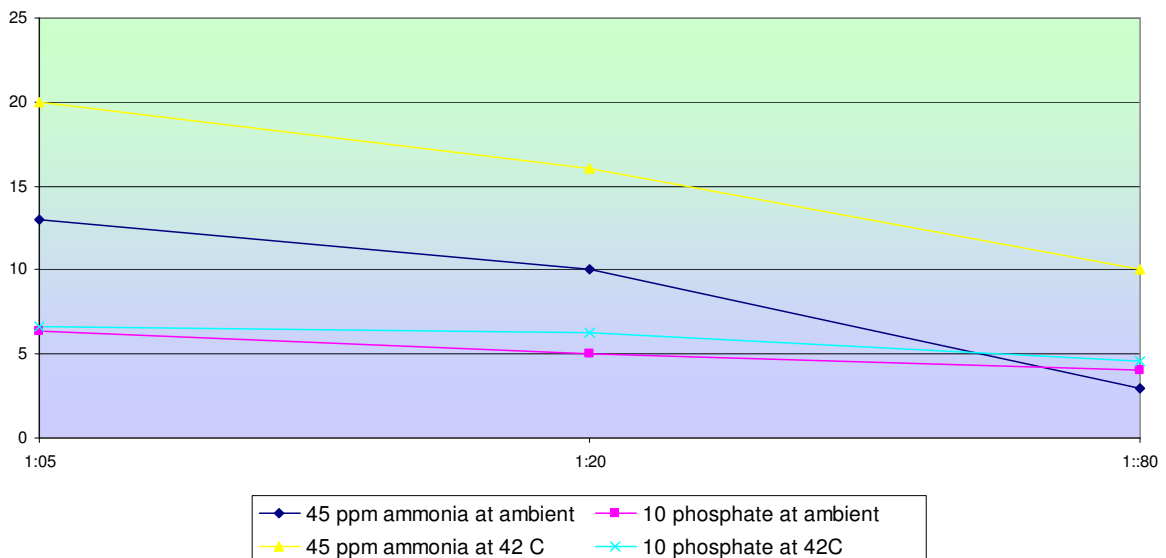


Table 10. Efficiency of bacteria

Dilution used Demi water with ratio 6:100:30 (P:BOD:N)				
Dilution ratio	Ammonia at 42 C		Ammonia at ambient	
	NH4	PO4	NH4	PO4
1 Nitrobacter	45 ppm	10 ppm	45 ppm	10 ppm
5,20,80 Nitrosomonas	45 ppm	10 ppm	45 ppm	10 ppm
1/5	20	6.6	13	6.4
1/20	16	6.25	10	5
1/80	10	4.7	3.	4

Fig: 11 Efficiency of bacteria with different temperatue and ratio 1:100:5 (P:BOD:N)

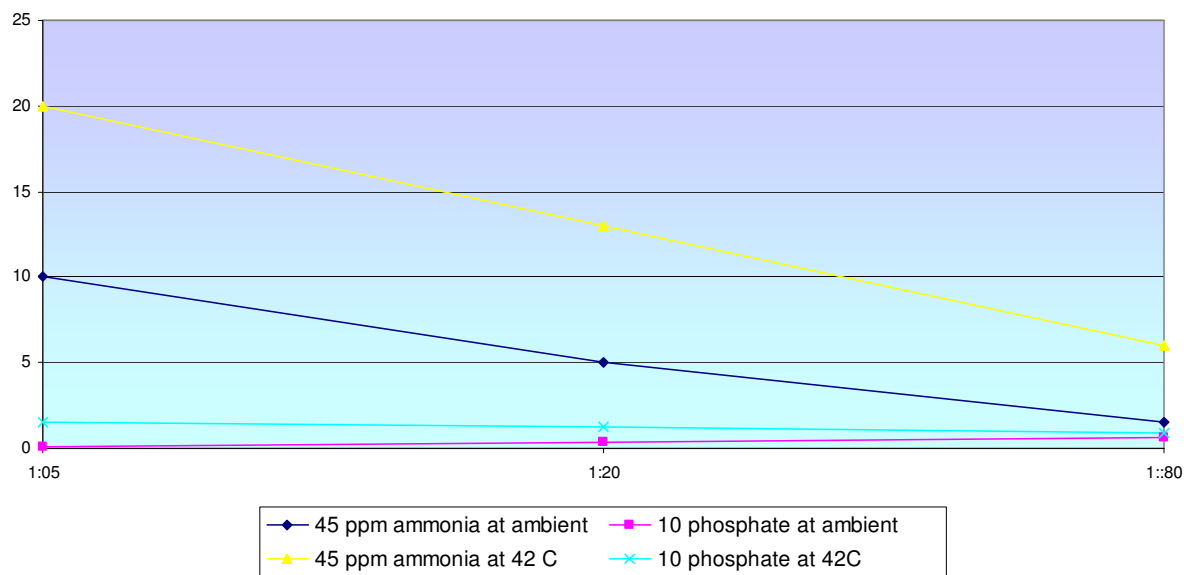


Table 11. Efficiency of bacteria

Dilution used Demi water with ratio 1:100:5 (P:BOD:N)				
Dilution ratio	Ammonia at 42 C		Ammonia at ambient	
	NH4	PO4	NH4	PO4
1 Nitrobacter	45 ppm	10 ppm	45 ppm	10 ppm
5,20,80 Nitrosomonas	45 ppm	10 ppm	45 ppm	10 ppm
1/5	20	1.5	10	0.625
1/20	13	1.25	5	0.375
1/80	6	0.875	1.5	0.125

Fig:12 Efficiency of pseudomonas aeruginosa with nitrifying bacteria to reduce nitrate

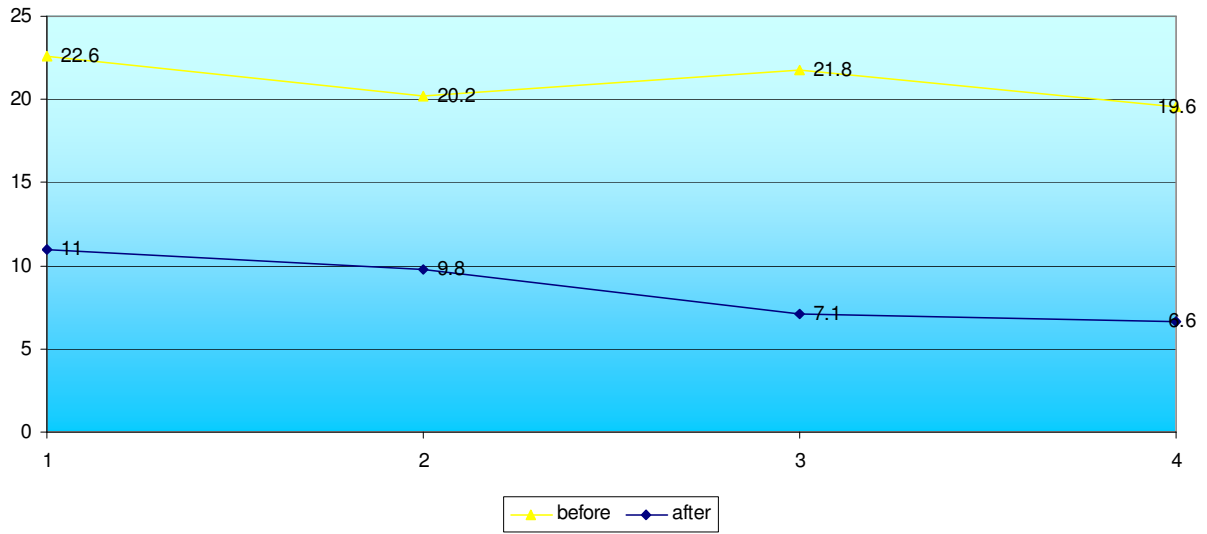


Table 12. Pseudomonas aeruginosa with nitrifying bacteria

Sample	NO ₃			
	1::5		1::80	
before	22.6	20.2	21.8	10.6
after	14.1	9.8	7.1	6.6

Fig: 13 Efficiency pseudomonas spires for reducing of NO₃ concentration

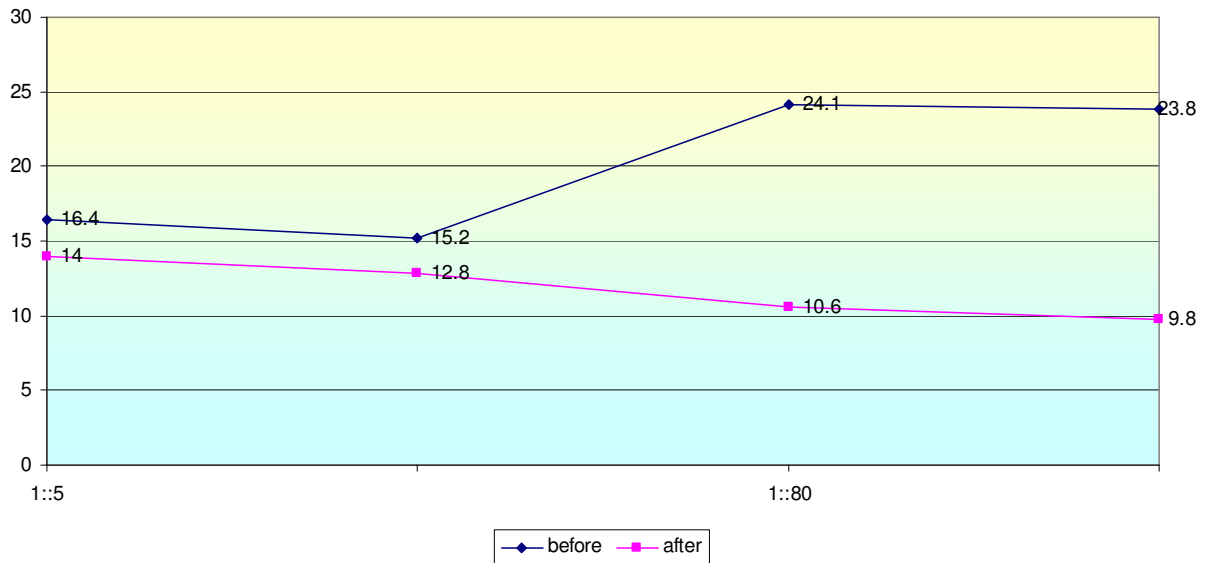


Table 13. Pseudomonas all species with nitrifying bacteria

Sample	NO3			
	1::5		1::80	
before	16.4	15.2	24.1	23.8
after	14	12.8	10.6	9.8

Fig 14: High removal of phenol concentration

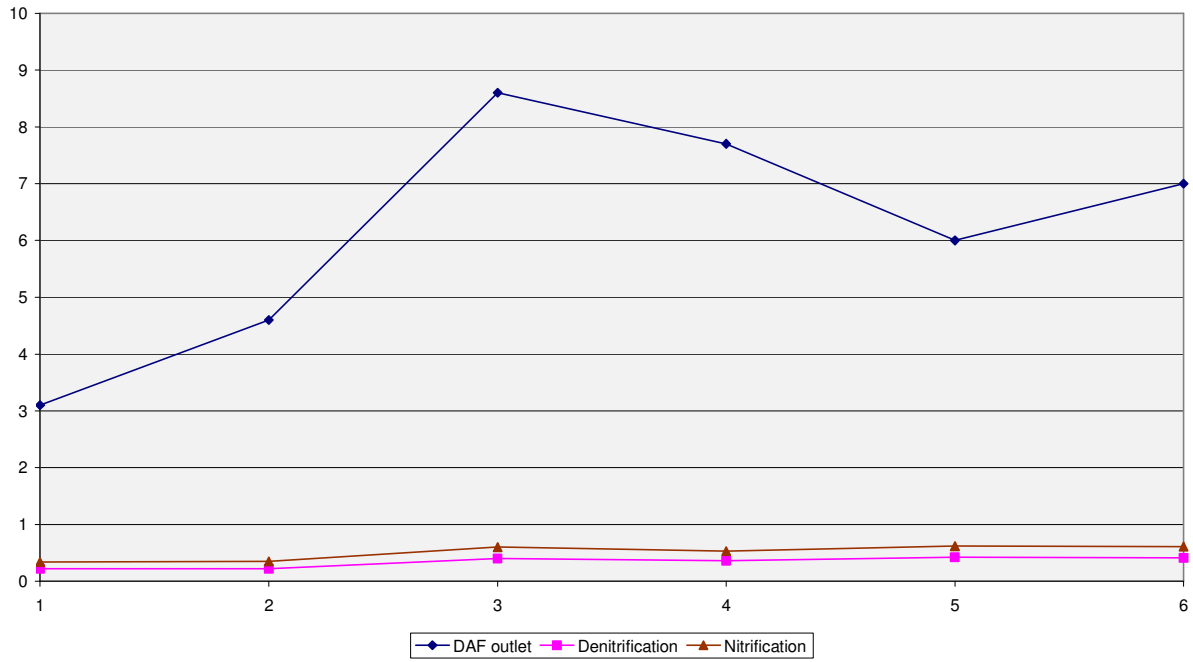


Table 14. Phenol concentration in ppm

DAF outlet	De-nitrification	Nitrification
3.1	0.22	0.34
4.6	0.22	0.35
8.6	0.4	0.6
7.7	0.36	0.53
6	0.42	0.62
7	0.41	0.61

Fig 15 High removal of BOD in biological step

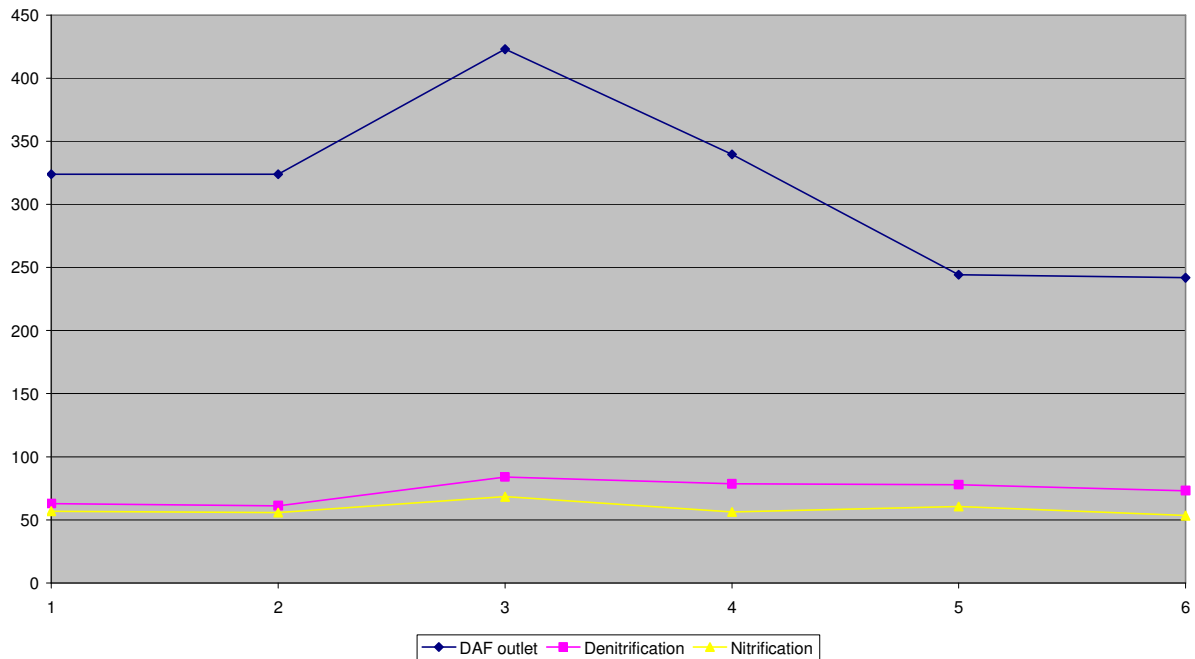


Table 15. BOD concentration in ppm

DAF outlet	Denitrification	Nitrification
324	63	57
324	61.2	55.8
423	84	68.4
399.6	78.6	56.4
244.2	78	60.6
241.8	73.2	53.4

From table: 1 and figure 1, we notice that:

- The efficiency of removal of ammonia is worse when the dissolved oxygen is less than 2 ppm and the efficiency of removal of ammonia is about 47%.

From table: 2 and figure 2, we notice that:

- The efficiency of removal of ammonia is better when the dissolved oxygen is more than 2 ppm and the efficiency of removal of ammonia is about 87%.

From tables: 3 and figure 3, we notice that:

- There is direct relation between BOD and ammonia.

From table 4 and figure 4, we notice that:

- The high efficiency of removal of ammonia is 60%.

From table 5 and figure 5, we notice that:

- The low efficiency of removal of ammonia is 27%

From table 6 and figure 6, we notice that:

- The low efficiency of removal of BOD is 19.3%.

From table 7 and figure 7, we notice that:

- The high efficiency of removal of BOD is 81%.

From tables: 8, 9, 10 and 10 and figures 8, 9, 10 and 10, we notice that:

- The best ratio for P: BOD: N is 1:100:5 respectively.
- The best ratio between both Nitrobacter and Nitrosomonas is 1:80 but practically ratio 1:15 is suitable for our case.
- The best temperature is between 30 to 35°C that is meaning ambient temperature.

From table 14 and figure 14, we notice that:

- The removal of phenol concentration in biological treatment increased.

From table 15 and figure 15, we notice that:

- The removal of BOD increased.

From table 12 and figure 12, we notice that:

- The total bacteria count of pseudomonas aeruginosa is $10 * 10^4$.
- This TBC has efficiency for removal NO_3 is 57.6% for ratio 1:5 (Nitrobacter : Nitrosomonas) and 64.6% for ratio 1:80(Nitrobacter : Nitrosomonas).

From table 13 and figure 13, we notice that:

- The total bacteria count of all species of pseudomonas is $35 * 10^4$.
- This TBC has efficiency for removal NO_3 is 15% for ratio 1:5 (Nitrobacter : Nitrosomonas) and 57% for ratio 1:80 (Nitrobacter : Nitrosomonas).
- Pseudomonas aeruginosa is more efficient than pseudomonas all species.

CONCLUSION

The biological treatment for the petroleum industrial wastewater treatment is one of the best methods to treat the industrial wastewater, This method concern to reduce important pollutants such as BOD, phenol and ammonia, To complete the biological treatment there are mainly three types of the bacteria pseudomonas bacteria which responsible for reduction of BOD and phenol in de-nitrification step and Nitrosomonas and Nitrobacter (nitrifying bacteria) which responsible for reduction of ammonia in nitrification step.

There are many factors affecting on the efficiency of the bacteria as temperature, pH, BOD concentration, Dissolved oxygen concentration, nutrients and total bacteria count

In this study we found the best temperature is ambient temperature (30 - 35°C), pH range 6.5 - 8.5, nitrification proceeds better when the concentration of soluble BOD is low (less than 20 mg/l), Nitrification has very low efficiency if dissolved oxygen concentrations drop to 2.0 mg/l (ppm) or less, The best ratio for the essential element (P:C:N) as nutrients is (1:100:5) and the ratio between nitrobacter to nitrosomonas is 1:80 but practically in our case study it is 1:15 and total bacteria count for pseudomonas aeruginosa is 10×10^4 is more efficient than pseudomonas all species with total bacteria count 35×10^4 .

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