

# Review on Changing Natural Nitrogen Cycle: Special Reference to Kingdom of Saudi Arabia

Dr Ram Karan Singh<sup>#1</sup>, Shwetang Kundu<sup>\*2</sup>

<sup>#</sup> Professor, Department of Civil Engineering, King Khalid University, Abha, Kingdom of Saudi Arabia.

<sup>\*</sup> UG student, Department of Civil Engineering, ITM University Gurgaon

<sup>1</sup>ramkaran.singh@gmail.com, <sup>2</sup>shwetkunds@gmail.com

**Abstract**— Nitrogen is one of the key elements in the atmosphere that decides how this environment turns out to be in future. In a way-the whole life of beings on Earth depends on this element. Even in marine life, Nitrogen holds a lot of importance since the enzymes and bacteria involved in these processes (Nitrogen fixation, Nitrification etc) are closely related to enzymes and processes in human beings. Over past few years, scientists have researched and discovered that nitrate formed and produced and used is harmful for human life. So various other forms of nitrogen are being used now after 1990. Nitrogen is being used all over the world in form of fertilizers and other chemicals. It's usage in India and China is extensive.

An urgent need arises to look into discrepancies in Nitrogen cycle and fix them. Specially Nitrate pollution needs to be checked regularly. Data is collected by various agencies all over the world about usage of Nitrate. Strict actions need to be taken against its use. The concept of sustainability needs to be stressed and all countries are coming forward for it-collecting and sharing information about nitrogen.

**Keywords**— Nitrogen Cycle, Major Nutrient, Greenhouse gases, Nitrogen fluxes

## I INTRODUCTION

If we want to survive the disaster we have caused by not paying any importance of sustainability, it is important that we work towards knowing our environment and it's elements better. When we work towards knowing the elements of this marvellous environment, we discover more and more about the meticulous working of the nature, which indeed helps us to realise the horrendous disaster we have caused and how we can now work to prevent it.

Specific bacteria (e.g., *Rhizobium trifolium*) possess nitrogenase enzymes that can fix atmospheric nitrogen (see nitrogen fixation) into a form (ammonium ion) that is chemically useful to higher organisms. As part of the symbiotic relationship, the plant converts the 'fixed' ammonium ion to nitrogen oxides and amino acids to form proteins and other molecules, (e.g., alkaloids).[7][8] In return for the 'fixed' nitrogen, the plant secretes sugars to the symbiotic bacteria. Legumes maintain an anaerobic (oxygen free) environment for their nitrogen-fixing bacteria[9].

Nitric oxide's rapid reaction with water in animals results in production of its metabolite nitrite.[10] The characteristic odour of animal flesh decay is caused by the creation of long-chain, nitrogen-containing amines, such as putrescine and cadaverine, which are breakdown products of the amino acids ornithine and lysine, respectively, in decaying proteins. Chemical processing, or natural fixation, are necessary to convert gaseous nitrogen into forms usable by living organisms, which makes nitrogen a crucial component of food production.[11][12] The abundance or scarcity of this "fixed" form of nitrogen, (also known as reactive nitrogen), dictates how much food can be grown on a piece of land.

Decay of organisms and their waste products may produce small amounts of nitrate, but most decay eventually returns nitrogen content to the atmosphere, as molecular nitrogen. The circulation of nitrogen from atmosphere, to organic compounds, then back to the atmosphere, is referred to as the nitrogen cycle (Figure 1).

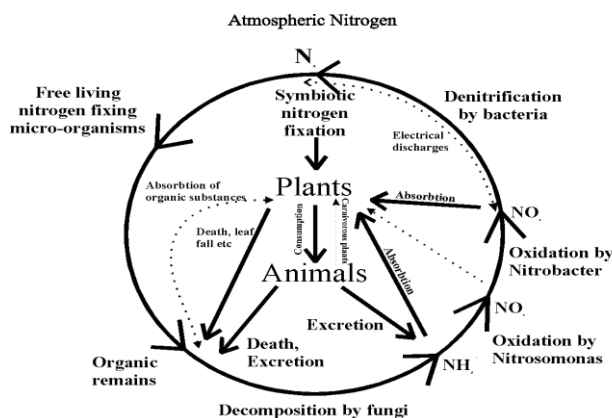


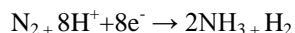
Fig. 1 General Nitrogen Cycle and its Movement in Biosphere

## II PROCESSES IN NITROGEN CYCLE

### A Nitrogen fixation:

Atmospheric nitrogen must be processed, or "fixed", to be used by plants. Some nitrogen fixing bacteria, such as *Rhizobium*, live in the root nodules of legumes (such as peas or beans). Here they form a mutualistic relationship with the plant, producing ammonia in exchange for carbohydrates. A few other plants can form such symbioses. Today, about 30%

of the total fixed nitrogen is manufactured in ammonia chemical plants.[17] [18].



### B Assimilation

Plants can absorb nitrate or ammonium ions from the soil via their root hairs. If nitrate is absorbed, it is first reduced to nitrite ions and then ammonium ions for incorporation into amino acids, nucleic acids, and chlorophyll.[19][20] In plants that have a symbiotic relationship with rhizobia, some nitrogen is assimilated in the form of ammonium ions directly from the nodules.

### C Ammonification

When a plant or animal dies, or an animal expels waste, the initial form of nitrogen is organic.[21] Bacteria, or fungi in some cases, convert the organic nitrogen within the remains back into ammonium (NH<sub>4</sub><sup>+</sup>), a process called ammonification or mineralization. Enzymes Involved are:

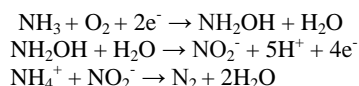
GS: Gln Synthetase (Cytosolic & Plastid)

GOGAT: Glu 2-oxoglutarate aminotransferase (Ferredoxin & NADH dependent)

GDH: Glu Dehydrogenase

### D Nitrification

In the primary stage of nitrification, the oxidation of ammonium (NH<sub>4</sub><sup>+</sup>) is performed by bacteria such as the Nitrosomonas species, which converts ammonia to nitrites (NO<sub>2</sub><sup>-</sup>). Other bacterial species, such as the Nitrobacter, are responsible for the oxidation of the nitrites into nitrates (NO<sub>3</sub><sup>-</sup>). Due to their very high solubility, and because soils are largely unable to retain anions, nitrates can enter groundwater. Nitrogen has contributed to severe eutrophication problems in some water bodies. Since 2006, the application of nitrogen fertilizer has been increasingly controlled in Britain and the United States.[22][23] This is occurring along the same lines as control of phosphorus fertilizer, restriction of which is normally considered essential to the recovery of eutrophied water-bodies.

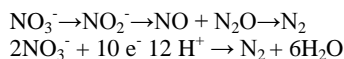


### E Denitrification

This process is performed by bacterial species such as Pseudomonas and Clostridium in anaerobic conditions. They use the nitrate as an electron acceptor in the place of oxygen during respiration. These facultative anaerobic bacteria can also live in aerobic conditions[24].

### F Anaerobic Ammonium Oxidation

In this biological process, nitrite and ammonium are converted directly into molecular nitrogen (N<sub>2</sub>) gas. This process makes up a major proportion of nitrogen conversion in the oceans.



Phytoplankton need nitrogen in biologically available forms for the initial synthesis of organic matter. Ammonia and urea are released into the water by excretion from plankton. Nitrogen sources are removed from the euphotic zone by the downward movement of the organic matter. This can occur from sinking of phytoplankton, vertical mixing, or sinking of waste of vertical migrators. Bacteria are able to convert ammonia to nitrite and nitrate but they are inhibited by light so this must occur below the euphotic zone. Ammonification or Mineralization is performed by bacteria to convert the ammonia to ammonium. Nitrification can then occur to convert the ammonium to nitrite and nitrate. Nitrate can be returned to the euphotic zone by vertical mixing and upwelling where it can be taken up by phytoplankton to continue the cycle.[25][26] N<sub>2</sub> can be returned to the atmosphere through denitrification.

As of now the best explanation for HNLC regions relates to iron limitation in the ocean. In recent years iron has become an important player when discussing ocean dynamics and nutrient cycles. The input of iron varies by region and is delivered to the ocean by dust (from dust storms) and is leached out of rocks. Iron is under consideration as the true limiting element in the ocean[27].

NH<sub>4</sub><sup>+</sup> and NO<sub>2</sub> show a maximum concentration at 50–80 m (lower end of the euphotic zone) with decreasing concentration below that depth. This distribution can be accounted for by the fact that NO<sub>2</sub> and NH<sub>4</sub><sup>+</sup> are intermediate species. They are both rapidly produced and consumed through the water column.[28] .

For India, from 2002-2008, consumptions of nutrients in Nitrogen Fertilizers have increased a lot as we can see from the figure.(Figure 2)

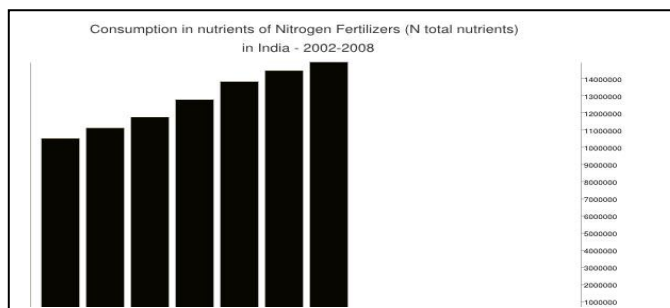


Fig 2: The Use of Nitrogen Fertilizer in India  
 III ATMOSPHERIC IMPLICATIONS

Activities indirectly enhance emissions to the atmosphere.[30]. Atmospheric N<sub>r</sub> inputs mainly include oxides of N (NO<sub>x</sub>), ammonia (NH<sub>3</sub>), and nitrous oxide (N<sub>2</sub>O) from aquatic and terrestrial ecosystems, and NO<sub>x</sub> from fossil fuel and biomass combustion.

In agro ecosystems, fertilizer application has increased microbial nitrification (aerobic process in which microorganisms oxidize ammonium [NH<sub>4</sub><sup>+</sup>] to nitrate [NO<sub>3</sub><sup>-</sup>]) and denitrification (anaerobic process in which microorganisms reduce NO<sub>3</sub><sup>-</sup> to atmospheric nitrogen gas [N<sub>2</sub>]). Both processes naturally leak nitric oxide (NO) and nitrous oxide (N<sub>2</sub>O) to the atmosphere. Of particular concern is N<sub>2</sub>O, which has an average atmospheric lifetime of 114–120 years, and is 300 times more effective than CO<sub>2</sub> as a greenhouse gas. NO<sub>x</sub> produced by industrial processes, automobiles and agricultural fertilization and NH<sub>3</sub> emitted from soils (i.e., as an additional by-products of nitrification) and livestock operations are transported to downwind ecosystems, influencing N cycling and nutrient losses[31].

Here is shown comparison between various countries in relation with nitrogen and fertilisers:

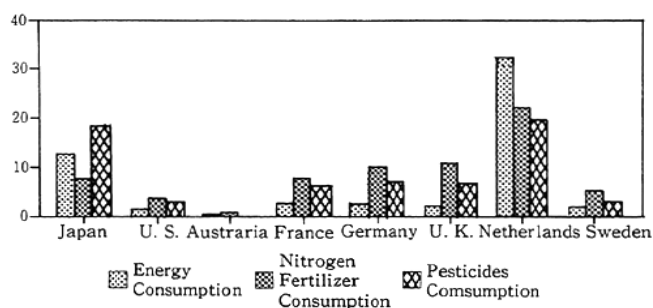


Fig 3: Global Consumption of Nitrogen Through Fertilizer, Energy and Pesticides

#### A Aquatic Ecosystems

NO<sub>3</sub><sup>-</sup> loading from N saturated, terrestrial ecosystems can lead to acidification of downstream freshwater systems and eutrophication of downstream marine systems. Freshwater acidification can cause aluminium toxicity and mortality of pH-sensitive fish species[35]. Because marine systems are generally nitrogen-limited, excessive N inputs can result in water quality degradation due to toxic algal blooms, oxygen deficiency, habitat loss, decreases in biodiversity, and fishery losses.

#### B Acidification of Freshwaters

NO<sub>3</sub><sup>-</sup> and NH<sub>4</sub><sup>+</sup> inputs from terrestrial systems and the atmosphere can acidify freshwater systems when there is little buffering capacity due to soil acidification pollution in Europe, the North-eastern United States, and Asia is a current concern for freshwater acidification.

#### C Eutrophication of marine systems

Tripling of NO<sub>3</sub><sup>-</sup> loads in the Mississippi River in the last half of the 20th century have been correlated with increased fishery yields in waters surrounding the Mississippi delta. However, these nutrient inputs have produced seasonal hypoxia (oxygen concentrations less than 2–3 mg L<sup>-1</sup>, "dead zones") in the Gulf of Mexico. In estuarine and coastal systems, high nutrient inputs increase primary production, which increase turbidity with resulting decreases in light penetration throughout the water column.[36][37].

Here is the N:K(Nitrogen: Potassium)comparison ratio for China, India and US over years from 1996-2012. As shown in figure, US has never been much of a user of Nitrogen, while it's usage peaks in India presently.

### IV MALICIOUS EFFECT OF NITRATE DUE TO ALTERATIONS IN NITROGEN CYCLE

#### A Health hazards due to nitrate pollution:

As reported by U Lahl [15], the primary effects of nitrate on man are very trifling e.g. irritation of the mucous membrane of the guts, secondary effects of the metabolism of nitrate to nitrite imposes considerable risk. Nitrate block haemoglobin in the red blood cells and inhibits oxygen transport. Especially infants in their first month are endangered due to the development of cyanosis and methaemoglobin anemia and nitrate content of drinking water was reported as early as 1962 by Sattlemacher of Federal Republic of Germany(FRG). A sufficient safety factor seems to be offered by a level of 10 mg/l for infants as a tertiary effect, the reaction of generated nitrate with special amine/amicle compounds in food or medicine has to be taken into account. Here, N-nitro compounds can be formed which is potent carcinogens in animals. Therefore, its similar effect on man cannot be excluded.

#### B Prescribed Limits of Nitrate Concentration in Ground Water:

Although health hazards created by nitrate concentration appears to be enormous, a uniform standard appears to be missing. WHO suggests quite a tolerant limit for nitrate concentration for Europe which may vary from 5-100 mg/l and for nitrogen to vary from 1.3 to 22.6 mg/l. EEC guideline in 1980 beginning from August 1985 suggest a limit of 50 mg/l for nitrate concentration which should be reduced to 25 mg/l in future. In USA nitrate concentrations are limited to 10 mg/l, though some researchers recommend it to be increased to 45 mg/l. In USSR nitrogen concentration limit is prescribed to be no greater than 10 mg/l. There is of course a need to be prescribe and keep a lower limit but in view of unavoidable factors that may lead to increased nitrate concentration a harmless suitable value needs to be worked out.

#### V SOURCES OF NITRATE POLLUTION TO GROUND WATER

Contribution of Nitrogen –nitrate from wet precipitation is not likely to be significant. Relatively low concentration of nitrates in surface and deeper aquifer samples tends to confirm this hypothesis. Handa [4] has reported a maximum value of 5 to 10 mg/l of Nitrate content in rainwater in India. In industrial regions with prevailing chemical plants, wind dispersed salt emissions could be a significant source of atmospheric nitrate which may get precipitated. Acid rains in certain areas may be responsible for decay of trees leading to partial release of nitrogen and SO<sub>2</sub> exhalation. It may also be of concern to note that contribution of nitrogen-nitrate from wet precipitation is reported to be increasing. In Czechoslovakia [18], 100 years ago it was estimated at 7.5 kg/ha/year, which at present is reported to be 15 kg/ha/year.

The soil nitrogen present in humus is also a factor of concern in certain regions. Nitrate in shallow ground water in large area of southern Alberta, southern Saskatoon, Montana is derived by oxidation and leaching of natural organic nitrogen in soil [10]. In Federal republic of Germany (FRG), Meiser [17], has reported that in a low moor soil 2 t N/ha is converted annually from organically bound nitrogen into Nitrate. However, a large portion is denitrified before it reaches to ground water. In a test area near Hanover the ploughing of grass land resulted in a loss of organically bound nitrogen by about 5t/ha in few years. About 70-80% of the lost nitrogen enters the ground water in the form of nitrate resulting in a temporary massive concentration. In the Zinty Ostrov region of Czechoslovakia [18] natural processes of mineralization of organic nitrogenous substance in the soil are predominant factor of increased nitrate –concentration of ground water. Not much systematic data has been collected, but it has been reported by Faster [8], that in some villages of Botswana where domestic water supply bore holes and pits latrines have coexisted for several years, the Nitrate concentration in ground water supplies from within Urban limits were between 20 to 50 mg/l whereas in the surrounding uncultivated areas they were less than 10 mg/l.

Industrial waste effluents especially those coming from fertilizers manufacturing plants have a definite impact on local ground water pollution. The test result from dug well in India [4] at Kanpur near such a factory indicates as high concentration as 516 mg/l of Urea and 315 mg/l of NH<sub>4</sub>. The process of growing a leguminous crop as a part of crop rotation as prevalent in many countries, is a source of Nitrate contamination. The amount of nitrogen fixed by grain legumes in India is about 60 to 80 Kg/ha most of which is removed as a part of grain. In Fodder legumes like berseem fixation may be as high as 400 kg/ha.

While exact source of nitrate to ground water cannot be specified, the main source appears to be fertilizer nitrogen. There has been many fold increase in the use of nitrogen fertilizers over the past decade in many countries of the world, as is shown in Table 1, and where as increase in the use of

phosphate, potassium and calcium has only been much smaller.

#### VI NITRATE POLLUTION OF GROUND WATER IN KINGDOM OF SAUDI ARBIA

In a research reported by Alabdula'aly Al, et.al. (2010) was undertaken in all 13 regions of the Kingdom of Saudi Arabia to assess the NO<sub>3</sub> contamination levels. The results indicated variation in nitrate levels from 1.1 to 884.0 mg/l as NO<sub>3</sub> throughout the Kingdom. The average nitrate levels in milligrams per liter (PPM) as NO<sub>3</sub> were as 65.7 (Jizan), 60.3 (Asir), 60.0 (Qassim), 51.3 (Hail), 41.8 (Makkah Al Mukaramma), 41.3 (Madina Al Munnawara), 38.0 (Al Baha), 37.0 (Najran), 30.7, (Tabouk), 25.2 (Eastern Province), 18.8 (Riyadh), 15.8 (Al Jouf), and 9.1 (Hadwed Shamalyah). The results indicated that nitrate levels exceeded the maximum contaminant limits for drinking water (45 mg/L as NO<sub>3</sub>) in a number of wells (n = 213) in different regions of the Kingdom. The maximum and minimum wells exceeding the maximum contaminant limits for nitrate in drinking water were in Jizan (52.6%) and Hadwed Shamalyah (4.9%), respectively. Most of the wells which exceeded the maximum allowed limits for nitrate were in the areas which were used for agricultural and residential purposes [56]. This means artificial fertilisers used in agriculture as nutrient may be source of contamination in groundwater.



Fig. 4: Depiction of thirteen Regions in the Kingdom of Saudi Arabia

### VII NITRATE POLLUTION OF GROUND WATER IN FEDERAL REPUBLIC OF GERMANY

The impact of agricultural use on increased nitrate concentration is clearly obvious from the data given in Table 2. A relation between nitrate concentration and agricultural land use is clearly recognizable in FRG. Large scale field studies reported by Meisser [17] in FRG has indicated that in case of sandy soils without winter crops about 100-120 mg NO<sub>3</sub>/l, 30 mg Cl/l, 1.5 mg Ca/l, 20 mg K/l and 8 mg Mg/l is normally expected in the upper most ground water zone where 100-120 Kg/ha of Nitrate fertilizer is being used. The contamination is especially greater for shallow wells than top upper aquifer. Within the federal state of North Rhine West Falia (NRW) nitrate concentration in drinking water of various water works has been found is given in Table 2.

TABLE 1  
 CONCENTRATION OF NO<sub>3</sub> IN VARIOUS WATER WORKS

Sl. No.	Concentration of NO <sub>3</sub> .mg/l	Number of water works
1.	<25	254
2.	25-50	79
3.	50-90	28
4.	>90	1

That the nitrate concentration is increasing steadily with time is obvious from the fact that Mussum water works operating since 1912 had a nitrate concentration of only 15 mg/l to begin with. It has steadily risen to 85 mg/l in 1981. The water works has to temporarily stop production in the spring of 1970 due to increase of nitrate concentration to a value of 130 mg/l. The impact of agricultural use on increase nitrate concentration is clearly obvious from the data given in Table 2.

TABLE 2  
 VARIATION OF NITRATE CONCENTRATION AS PER AGRICULTURAL USE OF LAND

Sl.No.	Type of agriculture	Nitrate concentration of groundwater mg/l
1.	Mainly green land (Meadows)	38
2.	Greenland, arable land (intensively used)	78
3.	Arable land (normal use), Green land, arable land (intensively used)	85
4.	Mainly arable land (intensively used)	101

In one of the most important wine growing areas of FRG 26 randomly selected samples from different public water supplies showed that 31% samples had nitrate concentration above 50 mg/l with a maximum concentration of upto 400 mg/l has been obtained. One reason for this is washing out of Nitrate from cultivated soils depending upon the seasonally varying precipitation amounts and vegetation

rythems. In FRG short term upper values up to nearly 400 mg/l of nitrate concentration has been found in public water supplies, samples taken one or two weeks later showed only 114 mg/l. Consumption of mineral fertilizer & yield in Germany since 1880 is given in Table-3 which shows consistent increase

TABLE 3: CONSUMPTION OF MINERAL AND YIELD IN GERMANY SINCE 1880:

Year	N*	P <sub>2</sub> O <sub>5</sub> *	K <sub>2</sub> O*	Wheat#	Barley#	Potato#
1880-85	0.7	1.6	0.8	12.8	12.9	79.2
1910-14	5.1	16.1	12.6	20.2	19.4	129.0
1939-43	21.0	14.0	46.2	21.9	20.7	175.2
1949-51	24.0	27.4	42.8	27.1	24.9	215.5
1959-61	42.5	47.3	71.4	32.7	29.0	223.9
1969-71	77.1	63.0	82.1	41.4	35.9	272.5

\* Consumption (Kg) per ha of agricultural land  
 # Yield (t/ha)

### VIII NITRATE POLLUTION IN GROUND IN CZECHOSLOVAKIA

In two regions of Czechoslovakia i.e. middle region in Bohemia and Danube low land in Slovakia. With high intensity of agricultural activities and important shallow of vulnerable, aquifers, the relationship between agro system and groundwater quality is being studied in great detail. The middle Elbe region of Bohemia has thousand year long history of farming, the contents of ground water in some parts of the area has increased three folds from 1955-1982.

### IX NITRATE POLLUTION IN INDIA

The Nitrate content of ground water has been varying in different parts of the country. The concentration of Nitrate in some dug wells in the UP for observation during years 1976-1981 has been shown to range from 20-180 mg/l with highest value of 1302 mg/l observed in the dug well in Agra District.

Than 10 mg/l. (Primary drinking water standard in USA) Extensive use of fertilizers much more than that needed by crop is suspected to be the main reason for this increase. Maximum NO<sub>3</sub>-N concentration occurred within 3.0 m of the surface in 21 of the 26 test wells. In some cases at depths of 4.6m, 9.1m and 13.7m as well the maximum concentrations has been observed. Bedding of

layers of low porosity material at different depths is suspected to be the cause of this variation.

#### X NITRATE POLLUTION OF GROUND WATER IN SWEDEN

The agricultural influence on the quality of ground water (1) is mostly associated with infiltration areas. A substantial lowering of ground water occurs during years of low precipitation. However, nitrate contents in all countries in the wells have been found to be lower than 40 mg/l. The above listed factors affect ground water quality on a complex manner, but to varying degrees of intensity depending upon the specific conditions in different regions.

The Czechoslovakian experience (18) indicates that in aquifers covered by a permeable unsaturated zone of small thickness, proportion was usually observed between nitrate concentration of ground water and the thickness of unsaturated zone. This phenomena is caused by sorption capacity on unsaturated zones where capillary forces can detain with in intergranular pore a greater volume of contaminated water which is washed out in to the aquifer especially in periods of increased recharge e.g. precipitation period. Further in Czechoslovakia the nitrate concentration is found to be maximum during the first three months and minimum during the last three months. It is presumed that mobile nitrogen compounds are released in to the hydrosphere through cyclic, random and systematic processes.

The Swedish experience indicates that hydrodynamic pressure is an important factor. A substantial lowering of the ground water occurred during the agrihydrological years 75 to 77, when the ground water reservoirs were filled up again, after precipitation reverted to normal, the waste percolating the soil profiles had a very high nitrate concentration. This was presumably an effect of a nitrate accumulation during preceding dry periods. The nitrate content of the shallow ground water increased considerably, when normal conditions were established the nitrate contents decreased and after four years the content was restored to the same level as before ground water depression.

The type of soil has also been found to be a factor of considerable importance according to Swedish experience. The possibility of substantial differences as regards the nitrogen losses through leaching has been indicated by experiments on three types of soils in the southern area of Sweden. The sandy soil lost more than twice as much nitrogen compared with clayey soil. The root depths in sandy soil rarely exceeds 40-40 cm. Nitrogen below this level is naturally not available to crops and is expose to leaching. For clayey soil with good structure the root penetration easily reaches one meter and more which results in more stable up take of nitrogen by crops.

#### XI DETERMINATION OF POTENTIAL NITRATE CONTAMINATION

In the methodology as a first step the main factors affecting the formation of nitrogen in ground water is established by determining the proximity of relations between nitrogen compounds and the dissolved solid contents, chlorine ion (Cl) sulphate ion (SO<sub>4</sub>), hydrocarbonate ions (HCO<sub>3</sub>), sodium ion (Na) calcium ion (Ca), Magnesium ion (Mg) and pH, by means of the correlation analysis. For an aquifer system in quaternary sandy argillaceous alluvial deposit, good correlation has been found between the NO<sub>3</sub> concentration on one hand with concentration of SO<sub>4</sub>, Mg, NH<sub>4</sub> in consecutive order. Following relationship has been found which may be considered specific to the region under study.

$${}^c\text{NO}_3 = 0.018 - 0.0013 {}^c\text{SO}_4 + 0.117 {}^c\text{Mg} - 0.342 {}^c\text{NH}_4$$

In the analysis of ground water samples with nitrate concentration less than 50mg/l only has been analysed and investigated. Eq. (1) enables us to obtain the nitrate ion content if concentration C for SO<sub>4</sub>, Mg and NH<sub>4</sub> in mg/l is known and is assumed to be natural called <sup>c</sup>NO<sub>3</sub> (natural). The areas of potential contamination of ground water are located by comparing the actual content of nitrate compounds <sup>c</sup>NO<sub>3</sub> (Actual) to the natural content <sup>c</sup>NO<sub>3</sub> (natural). Thereafter the following assumption is envisaged.

$$\text{If } \frac{{}^c\text{NO}_3(\text{actual})}{{}^c\text{NO}_3(\text{natural})} < 1$$

The accumulation of nitrogen compound is below its natural value, such a source may be used for drinking purposes.

$$\text{If } \frac{{}^c\text{NO}_3(\text{actual})}{{}^c\text{NO}_3(\text{natural})} = 1$$

Further accumulation of nitrogen compounds is likely to bring about harmful concentrations.

$$\text{If } \frac{{}^c\text{NO}_3(\text{actual})}{{}^c\text{NO}_3(\text{natural})} > 1$$

A zone of ground water potential contamination by nitrogen compounds is formed. The quality of water needs to be carefully monitored.

#### XII STRATEGIES FOR LIMITING NITRATE POLLUTION

Some of the major strategies suggested are:

1. Making use of optimal amount of fertilizer leading to maximum utilization of fertilizers by crops.
2. Shortening the time when the soil remains without vegetative cover.
3. Reduction of plant nutrition, which at present time exceeds profitable limits.

4. Creation of farming conditions necessary for the maximum assimilation of applied fertilizer by crops.
5. Search for a new type and form of fertilizer having a low migration capacity.
6. Development of regulation and technological methods of storing, transporting and using fertilizers eliminating their losses and subsequent entry into water.
7. Development of norms and rules regulating farming in water side zones, especially in the zone of intakes of drinking water supplies.

It has also been suggested (7) that the problem of what other nitrogen compounds and to what extent they should be used for replacing nitrate compounds in agriculture should be solved by joint efforts of agrobiologists, agrochemists, soil scientists and economists. It is quite possible that a particular solution of this problem can be found also by creating new preparative forms of nitrate fertilizers themselves which would be washed out of soil with difficulty and would not migrate over its profiles.

### XIII CONCLUSIONS

The nitrogen cycle works on a really delicate balance. It's of extreme importance that nitrogen cycle should not be altered. All countries need to work for this in a systematic and controlled way. It has been established that nitrate pollution is wide spread and alarming. However, data from developing countries are not available, which indicates that sufficient awareness has not developed in many countries about ground pollution in general and nitrate pollution in particular. Water authorities in different countries of the world should become alive to the situation. A proper standard for different regions for nitrate pollution should be worked out and a strategy is to be adopted to combat it. Research should be started for producing a fertilizer which may lead to high yield but does not give rise to ground water pollution. Strategies suggested in this paper should be properly studied with respect to its technical and economic feasibility and recommendation of adoption of a given strategy for a region should be prepared in the form of charts and tables.

### ACKNOWLEDGEMENT

We would like to express our sincere thanks to Prof. Dr. Hussein Manie Ahmed AL Wadai Dean College of Engineering, King Khalid University, Abha City and Dr. Ibrahim Falqi, Vice Dean for providing us encouraging environment for the research.

### REFERENCE

[1] Crosswell, Ken (February 1996). *Alchemy of the Heavens*. Anchor. ISBN 0-385-47214-5.

- [2] Meyer, Daved M.; Cardelli, Jason A.; Sofia, Ulysses J. (1997). "Abundance of Interstellar Nitrogen". *The Astrophysical Journal* 490: L103–L106. arXiv:astro-ph/9710162. Bibcode:1997ApJ...490L.103M. doi:10.1086/311023.
- [3] Reich, Murray; Kapenekas, Harry (1957). "Nitrogen Purification. Pilot Plant Removal of Oxygen". *Industrial & Engineering Chemistry* 49 (5): 869–873. doi:10.1021/ie50569a032.
- [4] Bartlett, J. K. (1967). "Analysis for nitrite by evolution of nitrogen: A general chemistry laboratory experiment". *Journal of Chemical Education* 44 (8): 475–346. doi:10.1021/ed044p475. edit
- [5] Eremets, M. I.; Popov, M. Y.; Trojan, I. A.; Denisov, V. N.; Boehler, R.; Hemley, R. J. (2004). "Polymerization of nitrogen in sodium azide". *The Journal of Chemical Physics* 120 (22): 10618–10623. doi:10.1063/1.1718250. PMID 15268087.
- [6] Rakov, Vladimir A.; Uman, Martin A. (2007). *Lightning: Physics and Effects*. Cambridge University Press. p. 508. ISBN 978-0-521-03541-5.
- [7] Jama, Bashir; Ndufa, J. K.; Buresh, R. J.; Shepherd, K. D. *Vertical Distribution of Roots and Soil Nitrate: Tree Species and Phosphorus Effects* 62 (1). Soil Science Society of America Journal. pp. 280–286. Retrieved 2 January 2013.
- [8] Bothe, Hermann; Ferguson, Stuart John; Newton, William Edward (2007). *Biology of the nitrogen cycle*. Elsevier. p. 283. ISBN 0-444-52857-1.
- [9] Jahn, G.C.; Almazan, Liberty P.; Pacia, Jocelyn B. (2005). "Effect of nitrogen fertilizer on the intrinsic rate of increase of the rusty plum aphid, *Hysteroneura setariae* (Thomas) (Homoptera: Aphididae) on rice (*Oryza sativa* L.)". *Environmental Entomology* 34 (4): 938–943. doi:10.1603/0046-225X-34.4.938.
- [10] Knox, G. A. (2007). *Biology of the Southern Ocean*. CRC Press. p. 392. ISBN 0-8493-3394-6.
- [11] Nielsen, M. K.; Jørgensen, B. M. (Jun 2004). "Quantitative relationship between trimethylamine oxide aldolase activity and formaldehyde accumulation in white muscle from gadiform fish during frozen storage". *Journal of Agricultural and Food Chemistry* 52 (12): 3814–3822. doi:10.1021/jf035169l. PMID 15186102.
- [12] Vickerstaff Joneja, Janice M. (2004). *Digestion, diet, and disease: irritable bowel syndrome and gastrointestinal function*. Rutgers University Press. p. 121. ISBN 0-8135-3387-2.
- [13] Steven B. Carroll; Steven D. Salt (2004). *Ecology for gardeners*. Timber Press. p. 93. ISBN 978-0-88192-611-8.
- [14] Nitrogen Study Could 'Rock' A Plant's World". 2011-09-06. Retrieved 2011-10-22.
- [15] Schuur, E. A. G. (2011). "Ecology: Nitrogen from the deep". *Nature* 477 (7362): 39–40. doi:10.1038/477039a. PMID 21886152.
- [16] Morford, S. L.; Houlton, B. Z.; Dahlgren, R. A. (2011). "Increased forest ecosystem carbon and nitrogen storage from nitrogen rich bedrock". *Nature* 477 (7362): 78–81. doi:10.1038/nature10415. PMID 21886160
- [17] Moir, JWB (editor) (2011). *Nitrogen Cycling in Bacteria: Molecular Analysis*. Caister Academic Press. ISBN 978-1-904455-86-8.
- [18] Smith, B., R. L. Richards, and W. E. Newton. 2004. *Catalysts for nitrogen fixation : nitrogenases, relevant chemical models and commercial processes*. Kluwer Academic Publishers, Dordrecht ; Boston.
- [19] Willey, Joanne M. (2011). *Prescott's Microbiology* 8th Ed. New York, N.Y.: McGraw Hill. p. 705. ISBN 978-0-07-337526-7
- [20] Miller, Charles (2008). *Biological Oceanography*. 350 Main Street, Malden, MA 02148 USA: Blackwell Publishing Ltd. pp. 60–62. ISBN 978-0-632-05536-4.
- [21] Gruber, Nicolas (2008). *Nitrogen in the Marine Environment*. 30 Corporate Drive, Suite 400, Burlington, MA 01803: Elsevier. pp. 1–35.

- ISBN 978-0-12-372522-6.
- [22] Miller, Charles (2008). *Biological oceanography*. 350 Main Street, Malden, MA 02148 USA: Blackwell Publishing Ltd. pp. 60–62. ISBN 978-0-632-05536-4.
- [23] Boyes, Elliot, Susan, Michael. "Learning Unit: Nitrogen Cycle Marine Environment". Retrieved 22 October 2011.
- [24] Chapin, S.F. III, Matson, P.A., Mooney H.A. 2002. *Principles of Terrestrial Ecosystem Ecology*. Springer, New York 2002 ISBN 0-387-95443-0, p.345
- [25] Aerts, Rien and Berendse, Frank (1988). "The Effect of Increased Nutrient Availability on Vegetation Dynamics in Wet Heathlands". *Vegetatio* 76 (1/2): 63. JSTOR 20038308.
- [26] Camargo, J.A. & Alonso, A. (2006). *Ecological and toxicological effects of inorganic nitrogen pollution in aquatic ecosystems: A global assessment*. Retrieved December 10, 2010, from <http://www.aseanenvironment.info/Abstract/41013039.pdf>
- [27] Rabalais, Nancy N., R. Eugene Turner, and William J. Wiseman, Jr. (2002). "Gulf of Mexico Hypoxia, aka "The Dead Zone"". *Ann. Rev. Ecol. Sys.* 33: 235–63. doi:10.1146/annurev.ecolsys.33.010802.150513. JSTOR 3069262.
- [28] Dybas, Cheryl Lyn. (2005). "Dead Zones Spreading in World Oceans". *BioScience* 55 (7): 552–557. doi:10.1641/0006-3568(2005)055[0552:DZSIWO]2.0.CO
- [29] Galloway, J. N., J. D. Aber, J. W. Erisman, S. P. Seitzinger, R. W. Howarth, E. B. Cowling, and B. J. Cosby. 2003. "The nitrogen cascade". *Bioscience* 53:341-356 Alternatively: Galloway, J. N. 2003. "The Global Nitrogen Cycle". pp. 557-583 in H. D. Holland and K. K. Turekian, editors. *Treatise on Geochemistry*. Pergamon, Oxford
- [30] Alley et al. 2007. IPCC Climate Change 2007: *The Physical Science Basis. Contribution of Working Group I in the Third Assessment Report of Intergovernmental Panel on Climate Change*. Report Summary for Policy Makers (SPM).
- [31] Schlesinger, W. H. 1997. *Biogeochemistry : An analysis of global change*, San Diego, CA.
- [32] Smil, V. 2001. *Enriching the earth : Fritz Haber, Carl Bosch, and the transformation of world food production*. MIT Press, Cambridge, MA.
- [33] Galloway, J. N., and E. B. Cowling. 2002. "Reactive nitrogen and the world: 200 years of change". *Ambio* 31:64-71
- [34] Vitousek, P. M., and R. W. Howarth. 1991. "Nitrogen Limitation on Land and in the Sea - How Can It Occur." *Biogeochemistry* 13:87-115
- [35] Rabalais, N. N. 2002. "Nitrogen in aquatic ecosystems". *Ambio* 31:102-112
- [36] John T. Houghton, Y. Ding, D. J. Griggs, M. Nogue, P. J. van der Linden, X. Dai, K. Maskell, and C. A. Johnson. 2001. IPCC Climate Change 2001: *The Scientific Basis. Contribution of Working Group I in the Third Assessment Report of Intergovernmental Panel on Climate Change*. Cambridge University Press
- [37] Houdijk, A. L. F. M., P. J. M. Verbeek, H. F. G. V. Dijk, and J. G. M. Roelofs. 1993. "Distribution and decline of endangered herbaceous heathland species in relation to the chemical composition of the soil". *Plant and Soil* 148:137-143
- [38] Arne Gustafsson, "Leaching of Nitrates from Arable land into ground water in Sweden" International symposium "Impact of Agricultural activities on ground water" volume XVI, parts 2, proceedings Prague 1982.
- [39] Anonymous, "Ground water resources of Noycil, ponnal & vattamalai karai basin" Central Ground Board Govt. of India, Septamber, 1993.
- [40] Oberman, peter, "contamination of gournrd water in the lower Rhive region (FRG) due to agricultural activities" International symposium on Impact of Agricultural activities on ground water, proceedings, Volume XVI, part2, Prague 1982.
- [41] Handa, B.K., "Effect of Fertilizer use on ground water quality in India" "Proceedings of International symposium on ground water in water Resources planning, vol. Koblenz, FRG, September 1983.
- [42] Danchev, D. etal, "Effect of farming on under ground pollution in North East Bulgaria", "Proceedings of International symposium on Impact of Agricultural activities on ground water", vol. XVI, part 2 prague 1982.
- [43] Delavelle Miche, "Prevention of De L'enrichissement Deseawx souterraines en nitrate D' origine Agricole", proceedings of International symposium on graound water in water resources planning, vol II, kob; enz, FRG September, 1983.
- [44] Dy Khanov, N.N., slept Sov G.V., "protection of waters from chemical fertilizers used in Agriculture" "water resources (Vodnye Resursy), vol, 6, No. 6, Nov-Dec. 1979.
- [45] Foster, S.S.D., "Potable ground water supplies and low cost sanitary engg-how compatible" proceeding of Int. Symp. On ground water in water resources planning, Vol. II.
- [46] Foster, S.S.D., Bath A.H., "The distribution of Agricultural soil leachates in the unsaturated zone of British chalk" proceedings of Int-symp. On Impact of Agricultural activities on ground water, vol XVI part-2, Prague 1982.
- [47] Freeza, R.A., cherry, J.A., "Ground Water" prentice Hall Inc, 1979, chapter 9.
- [48] Fadrus, H.R. Kvets, "alimentary Nitrate Methemoglobinemia of infants and the anomalous under ground chemism is south Moravia region". Proceedings of Int-symp. On Impact of Agricultural activities on ground water, vol. XVI, part-2, Prague 1982.
- [49] Goldberg v.M., & Macioszczyk.A., "Ground water quality and ground water pollution control" "proceedings of the congerence for the methods of evaluation of ground water resources, congress of Vilnius, USSR, vol XV, 1979.
- [50] Jacks, G., Sharma V.P." Nitrogen circulation & Nitrate in ground water in an agricultural catchment in southern India" proceedings of International symposium on Impact of Agricultural activities on ground water, Vol., XVI, part-2 prague 1982.
- [51] Kelvin, J.M., Bradford W.L., "Distribution of Nitrate in the unsaturated zone and increases in the NO<sub>3</sub>-N concentration in rising ground water in some areas of California" "Proc. Of Int. symp. On Impact of Agricultural activities on ground water, vol. XVI, part-2, Prague 1982.
- [52] Lahl U. etal." Ground water pollution by nutrate" procof Int. Symp. On ground water in water resources planning, vol.II, held at KOBLENZ, FRG Sept., 1983.
- [53] Laszlo' Alfordi" *General report on Movement & Interaction of Nitrates& pesticides in the vegetation cover soil ground water rock system" proceedings of Int. symp. Of Impact of Agricultural activities on ground water* " vol. XVI, part-2, Prague 1982.
- [54] Meiser, P, "Influence of Agriculture on the nitrate content of ground water" proceedings of the Impact of water management projects on the Hydrological and engineering geological conditions of the Lithosphere 1-5 Oct 1985, Tasjhent, USSR. (center for International Project GKNT, Moscow 1987).
- [55] Mocik, A; Repka, T; "pollution of ground water in Zitny Island by Nitrogenous matter from Agricultural large scale production studies in model territory of Diarahan" *Proceedings of Int-Symp. "Impact of Agricultural activities on ground water"* . vol XVI, part 2, parague 1982.
- [56] Alabdula'aly Al, et.al. (2010) "Assessment of nitrate concentration in groundwater in Saudi Arabia", *Environ* 2010 Feb; 161(1-4):1-9



#### Biography



Dr Ram Karan Singh is presently Professor in the Civil Engineering Department, King Khalid University in the Kingdom of Saudi Arabia. He has over **22 years** of teaching, research, administrative, and consultancy experience in top institutions/universities in India (14 years) and abroad (8 years). He held various administrative positions such as **Dean** of Research and Development, **Head** of the department and **Head** of the Research, Development and Industrial Liaison in various universities during the tenure of his work. He is a member of various national and international academic, research and administrative committees.

Awarded by JSPS (Japan Society for the Promotion of Science) **Post-Doctoral Fellowship, Japanese Govt. (letter no. JSPS/FF1/185; ID No. P 02413)** for a period of 2 years from 2002-2004 to carry out "Diffuse pollution modeling of water environment of Japanese low land watersheds", in Japan at Department of Hydraulics Engineering, NIRE, Tsukuba Science City, Japan 305-8609, **JAPAN**. Also recipient of several **National and International awards** for research work in the area of his interest and academic excellence awards.

He has over **100 research papers** in reputed peer reviewed Journals and conference proceedings and two books.

He has visited all major continents on research, teaching and collaborative assignments some important one are Keimyung University, **South Korea** (December 2011), University of Michigan, Ann Arbor, **U.S.A.**(May,2011); Michigan Technological University, Houghton, **U.S.A.**(May,2011); NIRE, Tsukuba Science City, **Japan**(July,2002-July,2004); Dublin University, **Ireland** (September 2003).