The Dynamic Nitrogen Cycle: A Tool for Reactivating Proteins

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EXECUTIVE SUMMARY

Nitrogen cycle is one of the most important cycles found in terrestrial ecosystems. Nitrogen is resident in five ponds: vegetation, animal/marine matter, geological (fertilizers/ soil conditioners / solid waste dumps), atmosphere and sea/water courses.

It is well documented that the nitrogen cycle is dynamic and is continually adjusting to environmental changes, often those induced by humans. Nitrogen loss from fertilizer application and fresh organic wastes may cause imbalance of nitrogen cycle and do harm to our environment, while excess nitrogen in a certain pond can be harmful to living creatures.

There are seven main options of the dynamic nitrogen cycles, involving one or more of the five nitrogen resident ponds. Each option has a different nitrogen transaction period, ranging form 1-4 days (option 1) to more than 2000 years (option 6). The options are:

- products directly to human needs (option 1),
- products going to animal or fish and then going to human(option 2),
- product going to plant via fertilizer and then going to human (option 3),
- product going to plant via compost and then going to human (option 4),
- product going to aggregate (option 5),
- product goes to solid dump (option 6)
- and product goes to environment via combustion (option 7).

Humans shall develop ways to identify optimum nitrogen cycle options and take actions such as using sustainable energy to protect nitrogen cycle balance for future generations.

Of all the components of the nitrogen cycle none is more complex and least prioritized than the protein and amino acid sector. It is this sector that is critical in terms of its nutrient values to humans and animals, and as such it should play a more dominant role in our decision making.

A Dynamic Nitrogen Cycle Tool, which prioritizes the best use for under utilized proteins would provide managers of dumps, legislators and communities a powerful advice from which make legitimate decisions on the way we process these products.

The same device could then quantify losses and imbalances in the world's protein bowl when advocates of greater sterilization call for greater destruction of nutrients by increasing the Thermodynamic/ pressure requirements on our food stuffs.

A "Reactivated Protein Credit" market needs to be developed into a marketing tool which would foster good practice, punish denaturing of proteins. This would in a way have more legitimacy and validity then "carbon Credits" as we already have in existence a whole range of commodity trading and futures exchanges based on the currency of food and therefore there is the potential for these to underpin and fortify good management aspects of a Dynamic Nitrogen Cycle Tool.

INTRODUCTION

Nitrogen as an element of the air, seas, land, pastures and animal life plays a critical if not essential role in living matter.

Its existence in all of these ponds is finely tuned as it can neither be created nor destroyed.

Yet in can be transformed and with this transformation its capacity to be available for specific functions becomes an imperative.

The transformation of the nitrogen component from one form to another, or from one pool source to another is reliant on chemical or metabolic activity. This therefore will be a function of a distinct set of exposures between each transformation.

Changes from one pond to another without an immediate reciprocating measure must lead to imbalances in the cycle being achieved.

It must then follow that, nitrogen imbalances within any two pond, places at risk matters of environmental sustainability and brings into questions issues dealing with bio diversity.

It is mankind that since the early 20^{th} century has created the greatest imbalances in our nitrogen allocation. In fact our impact on this cycle is probably more cogent than with the carbon cycle or even water cycle.

The high rate of population increases, associated with a redefinition of our dietary habits, that has spanned and impacted across virtually all cultures has severely stressed our capacity to create food.

This in turn has forced us not only annex more resources for agricultural purposes but also to transfer nitrogen consumption from one resource pond to the other with scant disregard to the equilibriums of each zone.

Mineral nitrogen based fertilizers have formed a very important truss for the increased demand on agricultural products.

The refinement of our eating habits particularly take-ways have placed an emphasis demands for meat, fish and poultry based materials with large quantities of fats at the expense of carbohydrates, fibres and other vegetable matter.

This in turn has changed the normal percentage of legume and vegetable matter going directly into human consumption, by redirecting these materials at a greater rate to animal husbandry with the associated additional production losses.

As it is the human species that principally is in control of this activity then it must be incumbent on us to achieve higher efficiencies in the use of each nitrogen source, to maintain a balance and to do this by not

- Digging,
- Burning,
- effluenting,
- Aerating

viable sources of nitrogen that can be used directly or with minimal exposure into the human or animal food chain.

In our 25 year experience with the disposal of so called waste protein streams around the world we can identify massive quantities of proteins being either destroyed or deactivated.

Worse is the fact that activity is perpetuated in confrontation to existing knowledge and know how, thus depriving the world, but more particularly the third world of vital nutrition.

Our experience suggests the following.

Loss 1. **Approximately 50% of nitrogen used to produce food for animals and mankind is wasted in the production, harvesting, transportation, storage and treatment of the product**.

Within this group we need look at :

- Growing losses
- Fertilizing
- Mulching
- Soil management
- Vegetation clearing
- Denaturization
- Harvesting losses
- Energy losses
- Transformation losses
- Residual unused material
- Processing Odours
- Sterilization and health regulation losses
- Transportation losses
- Packaging losses
- Used by date losses
- Animal wastage
- Effluent

Loss 2 A further 10-20%, is lost with the consumer and before consumption.

Within this scope we have those losses encountered by:

- Domestic cooking and preparation
- Salvage
- Table losses
- Kitchen losses

- Restaurant waste
- Spoilage including “used by date”

Loss 3. Then we have about 20-50% of that intake being lost through the various bodily functions.

Of course these percentages represent total mass rather the nitrogen content.

But there is often the case where the nitrogen concentration is often higher in the waste stream than in the intake.

Eg Brewery wastes, poultry faecal matter.

This scope includes metabolic losses, gases and human body and body parts decomposition.

OBJECTIVE

The objective of this paper is to take the aforementioned points of nitrogen losses then in any specific transmutation process ascribe them to one or more of the **FIVE PONDS OF NITROGEN**.

With these developed then to put any transformation into a time frame so as to develop a **Dynamic Nitrogen Cycle**.

Then having this and applying that information with data on the imbalances being wrought by current society we can then use this to not only better direct our various waste streams into preferred ponds but also to develop a more holistic approach to the treatment of nitrogenous products. Thereby we can develop better and more effective processing techniques and resource recovery policy.

When you consider that current hygiene demands, as effective or ineffective as they may be, are inscribed into law without consideration of the net effect damage or distortion of our nitrogen cycle then we must be having serious impacts on the integrity of our environmental management programmes.

Eg. If German legislators require a pressure/ temperature time cycle to be imposed on the processing of meat and blood meals, then not only should the actual effectiveness of this form of sterilization come under scrutiny but also the fact that about half of the nitrogen in the product will be lost to the water/atmosphere ponds and that the manufacture of the thermodynamic condition may expend if greater nitrogen resources.

This paper aims to promote discussion and find practical ways to assess the Dynamic Nitrogen Cycle so that water management decisions can be better informed.

NITROGEN RESIDENT PONDS

a. **VEGETATION**

b. **ANIMAL / MARINE MATTER**

c. **GEOLOGICAL**

- For the purpose of this paper the Geological pond needs to be broken into 3 sub sections so as to cater for the varying time constraints of
- Fertilizers (both as sources and application)
- soil conditioners
- solid waste dumps

d. **ATMOSPHERE**

e. **SEA AND WATER COURSES**

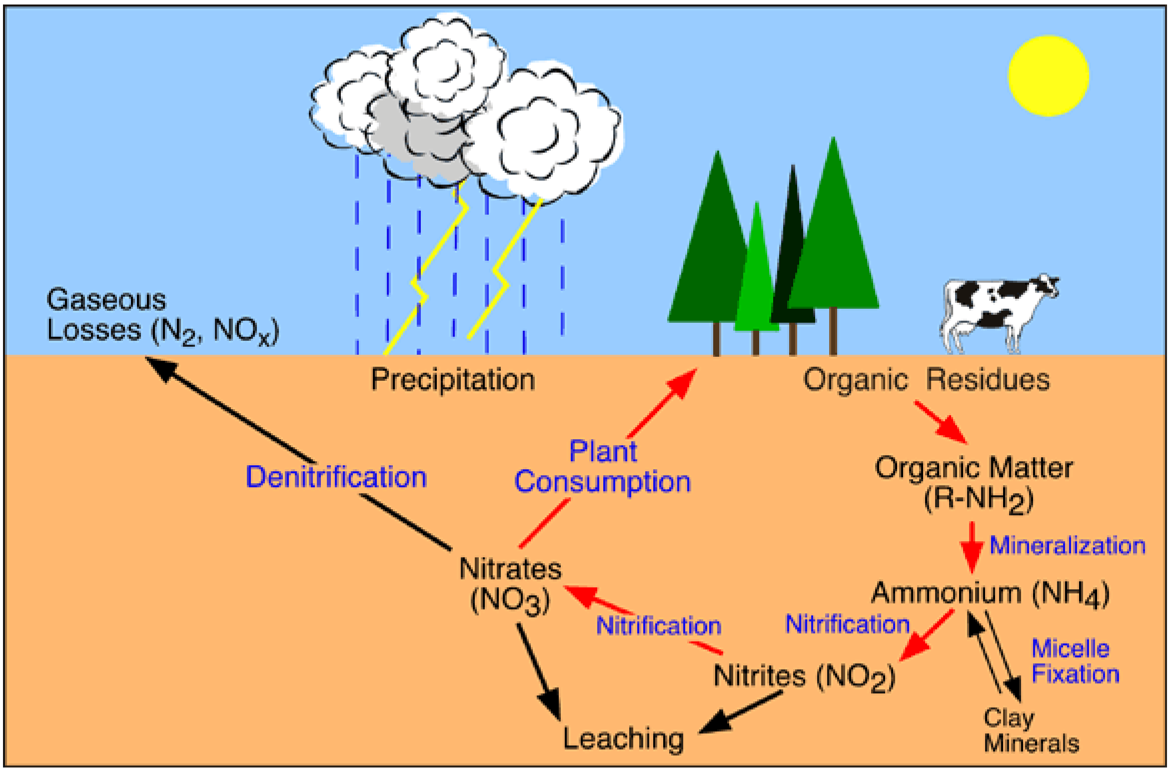
NITROGEN IS ESSENTIAL TO LIFE

Nitrogen is essential to the survival of all life on earth. It is an essential component of proteins, DNA, RNA, chlorophyll and other cellular constitutes.

Nitrogen, as a naturally occurring nutrient, plays many roles to ensure food consumed by human is bountiful and nitrous. Famine, sickness and suffering may occur if nitrogen intake is inadequate.

NITROGEN CYCLE

The nitrogen cycle is the whole process that converts atmospheric nitrogen into compounds useful to animals and plants, which eventually make their way back to atmospheric nitrogen. That is, all living organisms covert the nitrogen they require for life, growth and reproduction. With time, nitrogen recycles back into the environment through death and decomposition (please refer to the following figure).



(Source: http://www.geog.ouc.bc.ca/physgeog/contents/9s.html)

Figure 1. Nitrogen Cycle

Nitrogen widely distributed in five ponds including vegetation, animal/marine matter, geological (fertilizers, soil conditioners, solid waste dumps), atmosphere and sea / water courses. Nitrogen is converted from one pond to another.

Nitrogen can only be converted since it cannot be produced. Natural conversion includes fixation by lightning, fires and biological processes in the soil and atmosphere. Industrial fixation includes using of nitrogen fertilizer.

Nitrogen cycling is strongly dependent on climatic and environmental factors such as water availability and pH, salinity, aeration, forestation, type of vegetation and temperature.

Nitrogen element is inert while nitrogen compounds are active in foods, poisons, fertilizers and explosives. N_2 (nitrogen gas) forms NO and NO_2 with oxygen, ammonia (NH_3) with hydrogen, and nitrogen sulphide with sulphur. The main toxic oxides of nitrogen are NO and NO_2. N_2O is harmless. At high temperatures nitrogen will combine with certain active metals, such as lithium, magnesium and titanium to form nitrides.

Nitrogen makes up more than 3/4 of the air around us. Lightning causes some of the nitrogen and oxygen atoms in the air to combine, forming a compound, which then mixes with rain and other precipitation and falls to earth. Since most plants cannot use nitrogen in its gaseous form, nitrogen-fixing bacteria in root nodules convert atmospheric nitrogen into a form that other living things can use.

In most ecosystems nitrogen is primarily stored in living and dead organic matter. This organic nitrogen is converted into inorganic forms when it re-enters the biogeochemical cycle via decomposition. After nitrogen has been fixed by the bacteria, it circulates repeatedly between organisms and the soil. Denitrifying bacteria help regulate the amount of nitrogen in circulation by changing some fixed nitrogen back into a gas.

Decaying tissues from plants, animals or other organisms free, or release, the nitrogen atoms they contain. The next generation of organisms can then use these freed nitrogen atoms to make their own tissues. Not all the nitrogen compounds freed by decay are reused immediately, however. Instead, some are acted upon by various so called "denitrifying" bacteria. These bacteria get energy from decaying tissues. And in so doing, they convert some of the nitrogen in the rotting tissues into free nitrogen gas. This gas is released back into the environment where it's free to begin the cycle all over again.

OPTIONS FOR THE DYNAMIC NITROGEN CYCLE

There are many options of Nitrogen Cycle. The main seven options are illustrated as follows, *Days: 350 250 200 150 100 4*

Years: 2000 1000

Option1	Product	Human		
1-4 days	*1-4 days*			
Option7	Product	Burn		
1-90 days	*1-90 days*			
Option3.1	Product	Grass	Human	
61-154 days	*60-150 days via fertilizer*	*1-4 days*		
Option4.1	Product	Grass	Human	
>101-104days	*> 100 days via compost*	*1-4 days*		
Option2	Product	Meat/Milk	Human	
3-204 days	*2-200 days via animal or fish*	*1-4 days*		
Option3.2	Product	Grass	Meat/Milk	Human
63-254 days	*60-150 days via fertilizer*	*2-200 days via animal or fish*	*1-4 days*	
Option4.2	Product	Grass	Meat/Milk	Human
>103-304days	*> 100 days via compost*	*2-200 days via animal or fish*	*1-4 days*	
Option5	Product	Building		
1000 years	*1000 years*			
Option6	Product	Solid Dump		
2000 years	*2000 years*			

** The above scales are not in proportion. They only work as indications of positions within time frame. In above illustration, "Product" means anything in environment that contains nitrogen. "Nominal absorption period" means estimated time required to convert nitrogen from one source to another source.*

Figure 2. Nominal Absorption Period for Different Nitrogen Cycle Options

Option 1: Product directly from Human wastes.

Nitrogen cycle option 1 is the most direct nitrogen cycle. Nitrogen goes from environment to human waste directly. Then human waste is back to environment via decomposition. Nominal absorption period of Nitrogen cycle option 1 is 1-4 days since it takes approximately 1-4 days for human to convert nitrogen consumed to human waste. Nitrogen in human wastes can be in various chemical forms as follows:

Nitrogen forms	Liquid	Solid	Gas
Nitrogen Source	Urine	Faeces	Ammonia

A large amount of the nitrogen is lost from fresh organic wastes. NH_3 escapes into the air through volatilization and NO_3^- into waters through leaching (nitrogen components transform from animal/ marine matter pond to atmosphere pond and sea / water courses pond). These losses can add up to more than 2/3 of the nitrogen initially present.

Option 2: Product goes to Animal or Fish.

Animals get the nitrogen they need by eating plants or by eating animals that feed on plants. When animals eat these plants, they use some of the nitrogen to synthesize, or make, their own tissues.

The first step is nitrogen goes from environment to milk or meat (nitrogen components transform from vegetation pond to animal/ marine pond). It takes animal approximately 2 days to absorb nitrogen from environment to produce milk and it takes animal or fish about 200 days to absorb nitrogen to add meat. The second step is nitrogen goes from milk or meat to human waste since human drinks milk or eats animal/fish meat. Nitrogen cycle option 2 completed when human waste back to environment. Like Nitrogen cycle option 2, final nitrogen product is liquid from urine, solid from faeces, gas from ammonia, etc.

The first step takes 2-200 days and the second step takes 1-4 days. So the total absorption period of nitrogen cycle option 2 is 3-204 days.

Massive nitrogen emission is lost to the atmosphere from animal wastes (nitrogen components transform from animal / marine matter pond to atmosphere pond). Mass balance calculations of nitrogen emission from beef feedlots suggest that 50-65% of excreted nitrogen is lost to the atmosphere, or roughly 60-80 lb per steer per year. Estimated daily nitrogen loss for a single cow, based on total nitrogen, was 101 mg/d. Ammonia-nitrogen release was 77 mg N/d. Ammonia losses from open lot dairies in California, including the slurry manure storage, are about 80 lb per cow per year. Emission of ammonia for market hogs ranges between 19 and 30 lb per pig per year. Poultry ammonia emissions appear to be in the range of .5 to .6 lb per bird per year. Another way of looking at this, is that 15% of the organic matter originally in the manure was converted to ammonia within 72 h.

Option 3: Nitrogen goes from product to plant via fertilizer such as KNP.

Fertilizers are used to supplement the essential plant nutrients in the soil. Liquid fertilizer includes anhydrous ammonia, aqua ammonia, N solutions and liquid mixed fertilizers. Liquid N-P-K (nitrogen, phosphorus and potassium) fertilizers are also known as fluid fertilizer. They include true solutions that require no agitation and suspensions or slurry type mixtures of N, P and K, which require constant stirring to keep the solids suspended in the solution (http://lnweb18.worldbank.org/essd/essdext.nsf/51DocByUnid/2E4ED2DFC56A20B585256BA6007086D6/$FILE/HandbookMixedFertilizerPlants.pdf).

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Nitrogen Fertilizer	**Percent of N**
Anhydrous ammonia	82%
Nitrogen solutions	28~32%
Aqua ammonia	21%
Urea	46%
Ammonium nitrate	33%
Ammonium sulfate	21%
Calcium nitrate	16%
Potassium nitrate	13%
Sodium nitrate	16%

Table 2. Main Nitrogen Fertilizers

The two most common forms of N in fertilizers are ammonium (NH_4^+) and nitrate (NO_3^-). Under conditions of good plant growth, NH_4^+ is rapidly converted to NO_3^- by bacteria. Both forms can be taken up and utilized by plants. NH_4^+ is held in the soil by clay and organic matter. However, crops such as tobacco, potatoes and tomatoes prefer nitrate as their source of N. Because nitrate is much more mobile than ammonium, ammonium forms of N are recommended when the application is made prior to the time of greatest need. This practice minimizes potential loss by leaching.

In soil, ammonia reacts with water to form the ammonium ($NH_4^{+)}$ ion, which is held on clay and organic matter. The most favourable conditions for volatile N loss from surface-applied urea (solid or liquid) are alkaline soils, warm temperatures, intermediate relative humidity (50 to 90%) and sandy soils with low organic matter content and low cat ion exchange capacities.

When soils are excessively wet, nitrogen will be lost through the process of denitrification or leaching. The nitrogen loss will occur only from that portion of the fertilizer N that was in the nitrate from when soils became saturated. Because most fertilizers are applied as ammonium or a form that quickly converts to ammonium, amount of the applied nitrogen has been converted to nitrate shall be determined before fertilizer application. The rate of this conversion is dependent on soil temperature since the time of application and whether or not a nitrification inhibitor has been used.

De-nitrification is the major nitrogen loss method, particularly in medium- to heavy-textured soils. The higher the soil temperature, the more nitrogen that is in the nitrate will be lost. Research has shown that 4 to 5% of the amount of nitrate nitrogen present (note that this is not 4 to 5% of the total nitrogen applied) will be lost via de-nitrification for each day that soils are saturated when soil temperature is above 65 to 70°F. At temperatures less than 55°F, it is estimated that de-nitrification will be closer to 1 to 2% of the nitrogen that is in the nitrate form and increase to 2 to 3% when temperatures are between 55 and 65°F.

For nitrogen cycle option 3.x , the first step is the plants take up N from nitrogen fertilizers(nitrogen components transform from geological fertilizers pond to vegetation pond). Plants take up fixed nitrogen through their roots and pass it on in the form of proteins and amino acids to the rest of the food chain. This process takes about 60-150 days. Nitrogen cycle option 3.1 and nitrogen cycle option 3.2 are different from the second step.

For option 3.1, the second step is that human eat plants (nitrogen components transform from vegetation pond to animal pond). N goes from plants to human waste in 1-4 days. So total period of option 3.1 is 61-154 days.

For option 3.2, the second step is animal or fish eat plants(nitrogen components transform from vegetation pond to animal/ marine matter pond). Fish or animal consumes N in the plant and produces milk or meat in about 2-200 days. The third step is human consumes milk or meat of animal or fish. Then N in milk or meat is converted to N in human waste in 1-4 days. Thus total period for option 3.2 is 63-354 days.

Option 4: Nitrogen goes from product to plant via compost.

Adding compost into soil is an effective way to soften the soil. Decomposers in the upper soil layer modify the nitrogen in organic matter from ammonia to ammonium salts. Nitrogen in the form of ammonium can be absorbed onto the surfaces of clay particles in the soil.

For nitrogen cycle option 4.x , the first step is the plants take up N from compost in the soil (nitrogen components transform from geological soil conditioners pond to vegetation pond.) This process takes at least 100 days. Nitrogen cycle option 4.1 and nitrogen cycle option 4.2 are different from the second step.

For option 4.1, the second step is human eat plants (nitrogen components transform from vegetation pond to animal pond). N goes from plants to human waste in 1-4 days. So total period of option 4.1 is more than 101-104 days.

For option 4.2, the second step is animal or fish eat plants (nitrogen components transform from vegetation pond to animal / marine matter pond). Fish or animal consumes N in the plant and produces milk or meat in about 2-200 days. The third step is human consumes milk or meat of animal or fish. Then N in milk or meat is converted to N in human waste in 1-4 days. Thus total period for option 4.2 is at least 103-304 days.

Much of the ammonia originally in fresh manure is lost to the environment through volatilization. Significant loss (about 50%) of ammonia nitrogen can occur with splash plate application of slurry manure to the soil surface (nitrogen components transform from geological soil conditioners pond to atmosphere pond.). Ammonia is a nitrogen-containing compound and the nitrogen in ammonia is readily available to plants and bacteria. This ammonia-nitrogen loss reduces the value of compost and has been implicated in widespread damage to the environment. To examine the rate and time course of ammonia release from fresh manure, faeces and urine were collected from 6 mid-lactation cows over 24 h and subsequently mixed. The nitrogen loss represents 34% of the nitrogen initially in the manure and 134% of the nitrogen initially in the urine portion of the manure. Thus, urine nitrogen could account for only a portion of ammonia-nitrogen released. I
http://www.nal.usda.gov/ttic/tektran/data/000009/50/0000095011.html

Option 5: Nitrogen goes from product to aggregate.

Aggregate can be used as construction materials of buildings. It takes about one thousand years to turn the product to aggregate. So nominal Nitrogen absorption period for option 5 is 1000 years.

Option 6: Nitrogen goes from product to Solid dump

Nominal Nitrogen absorption period for option 6 (nitrogen components go to geological solid waste dumps pond) is 2000 years, the longest period among all options discussed in this article. That is because nitrogen is buried under ground for a quite long time in this option.

Option 7: Nitrogen cycle via burning the product.

Nominal Nitrogen absorption period for this option is 1-90 days. This is because that the storage period for product that contains N is 1-90 days.

Combustion is the rapid oxidation (combination with oxygen) of a fuel resulting in the release of usable heat and production of a visible flame. Fuel can be Methane, LPG (Propane Gas), Natural Gas, Diesel, Light Fuel Oils or Electricity.

Natural gas, a mixture containing about 75% methane (CH_4), 15% ethane (C_2H_6), and 5% other hydrocarbons, such as propane (C_3H_8) and butane (C_4H_{10}), also serves as a source of energy in fertilizer processing.

Natural gas occurs in reservoirs beneath the surface of the earth. It is often found in conjunction with petroleum deposits. Before it is distributed, natural gas usually undergoes some sort of processing. Usually, the heavier hydrocarbons (propane and butane) are removed and marketed separately. Non-hydrocarbon gases, such as hydrogen sulfide, must also be removed.

Natural gas consists mainly of methane, which is a highly flammable odorless gas. When methane burns, it leaves behind no ash and very little air pollution. Combustion of methane involves its reaction with oxygen in the air. Heat, light, carbon dioxide and water vapor are released.

The principal use of methane is as a fuel. The combustion of methane is highly exothermic.

$$CH_4(g) + 2\,O_2(g) \longrightarrow CO_2(g) + 2\,H_2O(l) \qquad \Delta H = -891\text{ kJ}$$

The energy released by the combustion of methane, in the form of natural gas, is used directly to heat homes and commercial buildings. It is also used in the generation of electric power. During the past decade natural gas accounted for about 1/5 of the total energy consumption worldwide.

Ammonia is one of the product of natural gas combustion.

Fossil fuel combustion, which produces NO to the air, causes the third largest disruption of the nitrogen cycle. Fossil fuel combustion 'mobilizes about twenty million metric tons of nitrogen per year.

NOx are soluble in water to form nitric and nitrous acids their effect is to cause irritation to the lungs and throat. Combustion could produce NOx by three ways as follows,

--The Thermal-NOx produced when the combustion proceed at high temperatures (above $1000^{O}C$) because the nitrogen contain in the combustion air will react with the existent oxygen.

--The Fuel-NOx will produce when the fuel contains nitrogen compounds and this reacts with the present oxygen. Any nitrogen already in the fuel will be oxidized even at relatively low combustion temperatures, such as one might find when wood burns in smouldering wildfires or coal in simple household stoves.

--The Prompt-NOx which is the way that produce the smaller amounts of NOx, consists in the rapid formation of NOx during the first stages of combustion process beginning with nitrogen and oxygen of the air(Smil 1997, p. 136).

High temperature combustion (as in gasoline and diesel engines) produces toxic gases in addition to carbon dioxide. For example, high temperature combustion of fossil fuels causes nitrogen in the air to react with oxygen producing toxic gases such as NO. NO is the more dangerous and is more toxic than CO. When nitrogen is heated under pressure with hydrogen, ammonia is formed. Nitrates are another by- products of combustion.

Fire causes NOx loss and N_2 loss from the product. For instance, the common practice of burning unused crop residues returned mineral nutrients to the soil, but it released nearly all photomaps nitrogen to the atmosphere (Smil 1997, p. 113). Also fire leads product to be deteriorated, following product breaking into numerous particles of protein.

While heat production generally has a negative effect on the quality of the product, some heat production may decrease the susceptibility of the product amino acids to degradation by rumina microbes. Mallard’s affect product is formed by cross linkage of amine groups with the carbonyl groups of carbohydrates when product is overheated which makes protein and carbohydrates indigestible. Generally heat production during conservation makes the product protein and carbohydrate indigestible and may reduce the palatability of the product (Stankiewicz et al 1998, p 282).

BALANCE AND IMBALANCE OF NITROGEN CYCLE

Nitrogen available to organisms was derived mainly from biological fixation and lightning in the past. However, in recent years availability has changed dramatically due to human activities.

Biomass burning and conversion/ land clearing of soils accelerate the mobilization of nitrogen (Stankiewicz et al 1998, p 1). One of the many environmental consequences, only now becoming clear, is significant disruption of the global nitrogen cycle. Nitrogen cycle is becoming imbalanced due to the following main reasons:

- increase of nitrogen fertilizers application and number of livestock
- fossil fuel combustion and forest burning
- car exhaust

Imbalanced nitrogen cycle is disrupting ecosystems in two important ways: by altering nutrient balances and by causing a net increase in global acidity. Ways to contradict nitrogen cycle imbalance are as follows:

- use renewable alternatives to fossil fuel

- minimise waste and use natural resources efficiently eg. improving animal management and feeding are ways to reduce N contamination of water resources.
- reduce volatile nitrogen loss from animal and manure storage facilities
- install catalytic converters on cars and design better engines and boilers to cut NOx emissions.
- reduce consumer demand for meat, particularly where per capita consumption is high enough to generate some health concerns.

The imbalances we currently are experiencing with the various Nitrogen Ponds and the their prognostications need careful determination. From this we should have a profile of the current status and a 50 year projection.

Knowledge of the dynamic nitrogen cycle can then be brought into relief against this background and variations, contrasted so that rebalancing priorities can be established.

It cannot be assumed that over the period of 50 years the one profile will remain valid, but it can be suggested that nitrogen audits of each pond will be a critical aspect of any valid "State of the Environment Study".

Once these are determined, then the priorities for waste disposal of nitrogenous products should be reviewed and modifications made to the disposal priorities so as to secure any required rebalance.

Further details on the imbalances of the nitrogen cycle and the ways to reduce these imbalances are provided in the Appendix**.**

RECOMMENDATIONS

1. There needs to be an International **"State of available protein"** report every five years.
2. Directives and remedial action should emanate from that report.
3. Managers of waste streams should then operate from guidelines developed from the studies.
4. That legislators, take into consideration the report when making deliberations on laws and project approvals.
5. A Reactivated protein Credit market needs be developed to underscore and highlight the needs and recommendations of the report.
6. Health regulators must benchmark their need for high sterilization against the report and be cognizant of the results, issuing from these deliberations.

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APPENDICES

Appendix I – Chemical Analyses of Fertiliser Materials

Table 1 contains the chemical analysis of these and other fertilizer materials.

Table 1—Primary and Secondary Nutrient Composition of Some Selected Fertilizer Materials[1]

Fertilizer Materials	Percent Water Solubility	Nutrient composition N	P_2O_5	K_2O	Ca	Mg	S
		%					
Nitrogen	N						
Ammonia, anhydrous	100	82	--	--	--	--	--
Ammonia, aqua	100	16-25	--	--	--	--	--
Ammonium nitrate	100	33.5	--	--	--	--	--
Ammonium nitrate-limestone	100	20.5	--	--	7.3	4.4	--
Ammonium sulfate	100	21	--	--	--	--	23.7
Ammonium sulfate-nitrate	100	26	--	--	--	--	15.1
Calcium cyanamide	100	21	--	--	38.5	--	--
Calcium nitrate	100	15	--	--	19.4	1.5	--
Nitrogen solutions	100	21-49	--	--	--	--	--
Sodium nitrate	100	16	--	--	--	--	--
Sulfur-coated urea	Variable	35	--	--	--	--	21

Urea	100	46	--	--	--	--	--
Ureaform	Variable	38	--	--	--	--	--
Phosphate	P						
Ammoniated super-phosphate	35	3-6	18-20	--	17.2	--	12
Ammoniated phosphate nitrate	100	27	15	--	--	--	--
Ammonium phosphate sulfate	90+	13-16	20-39	--	--	--	15.4
Ammonium polyphosphate	100	10-15	34-62	--	--	--	--
Bone meal	--	2-4.5	22-28	--	20-25	--	--
Diammonium polyphosphate	95+	16-21	48-53	--	--	--	--
Monoammonium phosphate	90+	11	48	--	1.1	--	2.2
Nitric phosphates	40	14-22	10-22	--	8-10	--	1-3.6
Phosphoric acid	100	--	52-60	--	--	--	--
Rock phosphate	<1	--	30-36*	--	--	--	--
Superphosphate, normal	85	--	18-20	--	20.4	--	11.9
Superphosphate, concentrated	87	--	42-50	--	13.6	--	1.4
Superphosphoric acid	100	--	69-75	--	--	--	--

Potash	K						
Nitrate of soda-potash	100	15	--	14	--	--	--
Potassium chloride (muriate)	100	--	--	60-62	--	--	--
Potassium magnesium sulfate	100	--	--	22	--	11.2	22.7
Potassium nitrate	100	13	--	44	--	--	--
Potassium sulfate	100	--	--	50	--	1.2	17.6
**Relatively unavailable to plants in most soils* [1]From *Fertilizer Handbook*, The Fertilizer Institute							

(Source: Vitosh M. L, N-P-K FERTILIZERS, Crop & Soil Science, http://www.msue.msu.edu/vanburen/e-896.htm)

Appendix II – Nitrogen Content of Legume Crops

Legumes contain more N than non-legume crops, and cool season grasses typically contain more N than tropical species. Forages contain more N when immature because the N is diluted by storage carbonhydrate and especially fiber as plants mature. In addition, some of the protein of mature plants is often bound and not digestible by animals. The leafy portion of plants contains more N than the stem portion, and whereas more forage protein is comprised of plant enzymes, the active parenchyma tissues contain more N than the less active sclerenchyma tissues (Stankiewicz et al 1998, p 279).

Appendix III - US Livestock Waste Nitrogen Lost

• • Animal Type	Number of Head	Amount of Waste (tons/yr)	Volume of Waste (gallons/yr)	Amount of Nitrogen in Waste(pounds/yr)	Nitogen Lost to Atmosphere (pounds/yr)	Amount of Phosphorous in Waste (pounds/yr)
Hogs	9,593,306	18,000,000	4,400,000,000	220,000,000	160,000,000	75,000,000
Cattle	953,197	7,300,000	1,800,000,000	81,000,000	39,000,000	20,000,000
Poultry	136,336,517	5,800,000	1,400,000,000	150,000,000	66,000,000	50,000,000
Sheep	12,618	5,100	1,200,000	110,000	77,000	22,000

Total Animal	146,895,638	31,000,000	7,600,000,000	460,000,000	270,000,000	150,000,000

***Note:** State totals are compiled using 1997 Census of Agriculture data, the most recent available data for this state. Please see a discussion of the limitations of animal waste data for more details.

- • **Animal Type Percentage Change in Animal Waste**

Hogs	Increased by 282% from 1987 to 1997
Cattle	Increased by 12% from 1987 to 1997
Poultry	Increased by 26% from 1987 to 1997
Sheep	Decreased by 2% from 1987 to 1997
Total Animal	Increased by 96% from 1987 to 1997

http://www.scorecard.org/env-releases/aw/state.tcl?fips_state_code=37

Amount of Waste (tons/yr)

Amount of waste is the weight, in tons, of feces and urine produced per year for a particular livestock type. Different types of animals produce different average amounts of waste per year. Scorecard uses waste factors to calculate the total amount of waste produced by a population of each particular animal type.

Volume of Waste (gallons/yr)

Volume of waste refers to the amount of space taken up by a given weight of animal waste produced, and is expressed in gallons per year. Different animal waste types have different densities and therefore, a given weight of waste from one animal type will occupy a different volume than the same weight of waste from a different animal type. Scorecard uses waste factors to calculate the volume of waste produced by a population of each particular animal type.

Amount of Nitrogen in Waste (pounds/yr)

This is the amount of nitrogen, in pounds, that can be found in a given amount (weight) of animal waste and can be calculated using a different nitrogen factor for each waste type. It is important to note that this quantity will differ from the amount of nitrogen sprayed onto fields because a significant quantity of nitrogen is volatilized before it is applied. The nitrogen in Scorecard's calculations is the nitrogen present in the waste at the time it is voided from the animal (i.e., leaves the animal's body). A considerable amount of nitrogen is volatilized, or lost to the air, as ammonia between the time it is voided and the time the waste is applied to a field. Ammonia volatilization occurs while the waste is still in the hoghouse, and the fans used for ventilation pump the nitrogen-laden air to the external atmosphere. Further volatilization occurs from the lagoon surface once the waste is transported to the lagoon. Finally, the process of spraying the lagoon slurry onto a field also causes loss of ammonia to the atmosphere. The amount of nitrogen being applied according to a certified waste management plan does not include the significant amount of nitrogen that is lost to the air during the processes described above. The volatilized ammonia ends up being deposited in precipitation or in dust particles some distance away.

Inorganic nitrogen predominately occurs as either ammonia (NH3) or nitrate (NO3), and is usually the limiting nutrient in marine ecosystems. A limiting nutrient is one which "limits" or controls the growth of primary producers, i.e., algae and other plants. Under conditions of N limitation, increases in nitrogen from any source, can result in rapid and excessive increases in algal growth.

When these algae die, the bacteria responsible for decomposition consume dissolved oxygen in the water column. Therefore, a massive "bloom" of algae can cause a severe drop in the level of dissolved oxygen, the result being that not enough oxygen is left for fish, crabs and other animals to breathe.

Nitrogen Lost to Atmosphere (pounds/yr)

The nitrogen in animal waste goes through many conversions-- and much of it can be volatilized, or lost to the air, as ammonia (NH3). Ammonia volatilization occurs while the waste is still in the hoghouse, and the fans used for ventilation pump the nitrogen-laden air to the external atmosphere. Further volatilization occurs from the lagoon surface once the waste is transported to the lagoon. Finally, the process of spraying the lagoon slurry onto a field also causes loss of ammonia to the atmosphere. These rates of loss to the atmosphere have been estimated for different animals. To obtain the total nitrogen lost, the number of animals is multiplied by the rate constant.

Amount of Phosphorus in Waste (pounds/yr)

This is the amount of phosphorus, in pounds, that can be found in a given amount (weight) of animal waste and can be calculated using a different phosphorus factor for each waste type.

Animal waste contains a significant amount of phosphorus, a nutrient which often limits algal growth in freshwater systems. Under phosphorus limited conditions, increases in phosphorus can spur the growth of algae. When these algae die, the bacteria responsible for decomposition consume dissolved oxygen in the water column. Therefore, a massive "bloom" of algae can cause a severe drop in the level of dissolved oxygen, the result being that not enough oxygen is left for fish, crabs and other animals to breathe.

http://www.scorecard.org/env-releases/def/aw_wastes.html#N_waste

Appendix IV - Balance and Imbalance of Nitrogen Cycle

Nitrogen available to organisms was derived mainly from biological fixation and lightning in the past. However, in recent years availability has changed dramatically due to human activities. Biomass burning and conversion/ land clearing of soils accelerate the mobilization of nitrogen (Stankiewicz et al 1998, p 1). One of the many environmental consequences, only now becoming clear, is significant disruption of the global nitrogen cycle. Nitrogen cycle is becoming imbalanced due to the following main reasons,

INCREASE OF NITROGEN FERTILIZERS APPLICATION AND NUMBER OF LIVESTOCK

With the world's ever increasing population and the upgrading of human diets, nature cannot provide sufficient nitrogen to sustain food demands. Most agricultural experts believe that increasing global demand for cereals and meat can be met, and forecast that grain production will rise by about 15 percent by 2010, and by 25 to 40 percent by 2020. As a result, nitrogen fertilizer industry has emerged and is essential to world food production.

Food consumption habit has been changing since last five decades. World cereal consumption has more than doubled in the last 30 years, while meat consumption has tripled since 1961. This causes booming of animal husbandry industry.

http://www.eurekalert.org/pub_releases/2003-06/uoca-cgn061203.php

In the past half century, the application of inorganic nitrogen fertilizers worldwide has increased more than nine fold, and the number of livestock has more than doubled since 1960. This trend leads large amount of nitrogen entering soils, freshwater and marine ecosystems (nitrogen component transform from fertilizers/ animal pond to geological pond, marine pond and sea / water courses pond). Currently, only far less than 50% of nitrogen applied to crops worldwide in fertilizer is actually utilized by growing plants. The rest becomes a pollutant, wasting farmers' money and imposing heavy costs on society in terms of clean-up requirements and lost productivity.

The application of nitrogen fertilizers and ammonia released from livestock wastes has caused increased rates of de-nitrification and leaching of nitrate into groundwater. In contrast to NH_4+, NO_3- is anionic, soluble and not retained in soils. Therefore, NO_3- from rainwater or fertilizers, or derived from the oxidation of soil organic matter and animal wastes, will wash out of soils and into rivers (Andrews et al 1996, p. 104). The additional nitrogen entering the groundwater system eventually flows into streams, rivers, lakes and estuaries. Groundwater contaminated by NO_3^- may cause several health problems including methemoglobinemia in infants and may also lead to stomach cancer. The added nitrogen (normally in the form of NO_3^-) may lead to eutrophication. The accumulation of dissolved nutrients in a body of water is called eutrophication, which will accelerate plant growth, often leading to algal blooms, and sometimes cause mass fish death through oxygen depletion.

In addition, a variable portion of the nitrogen excreted by animals (about 2%) is emitted to the atmosphere as nitrous oxide. Nitrous oxide is approximately 310 times as effective as carbon dioxide (per unit weight) in its global warming effect.

FOSSIL FUEL COMBUSTION AND FOREST BURNING

Fossil fuel combustion and forest burning, which release a variety of solid forms of nitrogen through combustion, cause deposition of nitrogen from atmospheric sources (nitrogen components go to atmosphere pond). Today humans are responsible for releasing about 40MT of NOx a year, split about 4:1 between oxides from fossil fuel combustion and oxides from the burning of phytomass (Smil 1997, p. 136).

The widespread use of fossil fuels releases nitrogen oxides. The combined effect of agriculture and fossil fuel combustion could be considered similar to natural nitrogen fixation, substantially modifying the global nitrogen cycle, creating important implications in a number of areas including global warming (related to NO), stratospheric ozone destruction(caused by N_2O), photochemical smog (contributed by NOx), and regional acid precipitation (caused by HNO_3 deposition). N deposition also results in changes in species diversity.

Volatized ammonia leads to acid rain, combines with other nitrogen and sulfur pollutants to form small air-borne particles that reduce air quality and threaten human health, and results in nitrogen deposition and over-fertilization of fragile ecosystems. Acid precipitation is also making many of our waterways so acid that a large number of aquatic species, many of which are of great commercial importance, are being seriously harmed.

NO is a Greenhouse gas. It also reacts with water and oxygen in the air to form dilute nitric acid. This contributes to Acid Rain.

NOx react with volatile organic compounds (VOC) and CO. The three ingredients develop very high concentrations of photochemical smog, a mixture of gases resulting from complex chains of chemical reactions powered by sunlight.

The process of ozone destruction starts with a rapid oxidation of NO to NO_2 involving a variety of reactive molecules (OH., CO, hydrocarbons, aldehydes). The subsequent dissociation of NO_2 and oxidization of hydrocarbons leads to rising concentrations of ozone (O_3). Tropical forest soils are probably the most important source of N_2O emission to the atmosphere. When N_2O is eventually mixed into the stratosphere, its reactions with excited oxygen (derived from the photo dissociation of ozone) produce NO, and that oxide sets off a catalytic cycle of reactions that leads to the destruction of ozone (Smil 1997, p.135). Troposphere ozone is also radioactive and there is good evidence that it is now about twice its pre-industrial concentrations. O_3 is harmful to most living creatures on earth. O_3 impairs lung function, injures cells, limits the capacity for work and exercise, and lowers the resistance to bacterial infections. In plants it causes pigmentation, bleaching of leaves, and tissue death, and it damages textiles, dyes, rubber, plastics and asphalt.

CAR EXHAUST

Car exhausts causes harmful NOx emissions (nitrogen component go to atmosphere pond). The pollution is produced at ground level (gasoline and diesel engine), mainly in cities in rush hours. N-containing compounds can also poison petroleum-reforming catalysts and pyrroles are known to make liquid fuel unstable upon storage due to tar formation (Stankiewicz et al 1998, p 243).

Imbalanced nitrogen cycle is disrupting ecosystems in two important ways: by altering nutrient balances and by causing a net increase in global acidity.

First, a change in the availability of nitrogen can lead to differential growth of some species relative to others, resulting ecosystem disruption and a potential loss of biodiversity. This differential growth may occur because nitrogen is a 'limiting' nutrient in many ecosystems; that is, the amount of nitrogen available to certain species limits their growth. An increase in the level of fixed nitrogen in the water or soil stimulates the growth of previously 'limited' species, which in turn crowd out other species due to eutrophication.

Second, chemical processes are continually oxidizing fixed nitrogen. Because oxidized nitrogen, or nitrate, is a strong acid, the net result of these chemical processes is acid precipitation. Acid rain exhausts soil's alkaline buffering capacity, leading to the mobilization of metals that were bound to soil particles. The mobilization of toxic metals damages lake ecosystems and is thought by some to be a cause of the central European forest death. In addition, acid rain increases rock weathering and causes the leaching of nitrates from soil into groundwater. Increased ammonia volatilization, primarily attributed to the decomposition of cattle urea, partially reverses the acidification process. This reversal occurs because ammonia, which is alkaline, chemically neutralizes nitrate, which is acidic. Nevertheless, local pH disruptions -- whether they take the form of increases in acidity or alkalinity -- will affect local ecosystems. Some species will adapt to the change more quickly than others, leading to a loss of biodiversity. In sum, 'a rapid increase in bio-available nitrogen in any form is likely to lead to a loss of biodiversity.'

Ways to contradict nitrogen cycle imbalance are as follows,

First, we can use renewable alternatives to fossil fuel. These alternatives include Solar Photo Voltaic Power System (Solar Energy), Solar Hot Water Systems, Wind Turbines, Bio-Fuel Plantations, Hydroelectric Power, Tidal Power and Geothermal Power. There energy are renewable since they do not run out. They can often produce electricity cheaper than burning fossil fuels, and they are non-polluting.

Second, minimizing waste and using natural resources efficiently could be applied in farm and fisheries management to reduce costs and environmental impacts, potentially increasing both profits and productivity levels. Improving animal management and feeding are ways to reduce N contamination of water resources. Loss of ammonia gas from field-applied manure is affected by characteristics of the manure; the weather during and after manure application, presence of a growing crop, condition of the soil, and length of time manure is exposed to the atmosphere. The best way to minimize ammonia losses is to incorporate the manure during or immediately after application. Improvements in animal diet and management to increase the conversion of feed N to animal product by 50% would decrease N losses by 36-40% but improving manure availability to crops by 100% would only decrease N losses from the farm by 14%. The utilization efficiency for N consumed by cattle depends on digestibility, amino acid profile, and the propensity for destruction of amino acids during storage and digestion (Stankiewicz et al 1998, p 279). Both ammonia and nitrites are toxic at low levels to most fishes and invertebrates. Intervention methods by aquarists: water changes, chemical filtrates, sped-up complete biological cycling (wet-dry filtration, algal scrubbers, abundant, vigorous live rock, macro-algae) can be brought into play to successfully limit the "bottle-neck" accumulation of nitrates. Different initiatives have been taken to try and find methods to utilize these nutrients, for example, methods to harvest algae in choked-up bays and use it to fertilize fields. Though, in the long run, we must change our living habits so these compounds circulate effectively and the large scale spreading of poisons ends. http://www.vattenkikaren.gu.se/fakta/ovrigt/eutrofie/eutr03e.html

Approaches that can be taken to reduce volatile nitrogen loss from animal and manure storage facilities include:
- Separation of feces and urine by modifying barn floor or use of belt or scraper systems to effect separation of urine and feces.
-Frequent scraping of barn floor.
-Deep manure storage pits with a minimum of exposed surface area.
-Covering manure storage.
-Use of alum and aluminum chloride to reduce ammonia loss by 70% in chicken litter.
-Use of constructed wetlands to convert manure nitrogen forms into nitrogen gas.
-Reducing manure pH through direct acidification or through use of feed additives.
-Bio-filters to remove ammonia from building exhaust air.

http://forages.orst.edu/nfgc/topics.cfm?ID=174

Fourth, we install catalytic converters on cars and design better engines and boilers to cut NOx emissions. Since the early 1990's, car exhausts have been fitted with Catalytic Converters in an attempt to minimize road vehicle pollution. These employ transition metals such as rhodium, palladium and platinum to convert harmful emissions into less harmful substances. The obvious solution is to fit road vehicles with electric motors rather than gasoline engine and diesel engine. (Smil 1997, p. 194).

Fifth, Some reduction in consumer demand for meat might be possible, particularly where per capita consumption is high enough to generate some health concerns.