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Biological Nitrogen Harvesting From Aquatic Ecosystems-A New Scientific Vision

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Abstract

Nitrogen is used for various applications in addition to the agriculture production. Biological nitrogen harvesting from aquatic /sea bird dropping, known as 'Guano' opens new door for capturing nitrogen from the sea or aquatic ecosystems and rearing birds close to the fishery ponds/terrestrial water bodies. The present study takes account of various innovative developments that have been brought in management of nitrogen cycle and brings further advancement in the biological nitrogen harvesting from the aquatic ecosystems that will go eco-friendly long way in environmental improvement promotions. Thus, the new ancillary natural nitrogen producing source would lessen problem caused by pollution of water in the rivers, lakes and ocean etc. on one hand and become source of developing enterprises of immense applications for generating employment and income, on the other. The biological harvesting of nitrogen will provide avenues for linking hydro-ecosystem to the terrestrial ecosystem through birds for transferring nitrogen from hydro ecosystem to terrestrial eco-system. The up-scaling of the research for assessing the content of iodine from the guano will make further vast resource of biological iodine harvesting and bring its use in eradicating wide spread iodine deficiencies, goitre related hazards to human health.

Keywords: Aquatic ecosystem; Nitrogen; Nitrogen cycle; Biological nitrogen harvesting; Bird dropping

Introduction

Nitrogen (N) is the main source for primary productivity [1]. It constitutes all products of plants and animal body tissues. As it constitutes amino acid, the main constituent of DNA, that support life implicating no DNA, no life [2]. It occupies four fifth of the atmospheric gases and gets transformed in different compounds and compositions, described by nitrogen cycle [3,4]. Nevertheless, efforts on production of food causes excess as well as nitrogen mining leading to situation of misbalance under both the circumstances. Nitrogen gets transferred from rural to urban areas. Discrepancies of proper treatment of sewages and its release in the water bodies cause eutrophication in the water bodies and many other environmental disasters [5] and its surplus cause's imbalance in the nitrogen cycle that leads to many environmental disasters. Nitrogen is the main source of primary productivity and its surplus causes imbalance in the nitrogen cycle that leads to many environmental disasters [4,6]. The improvement in the misbalance in the nitrogen cycle is being considered for substitution of organic and biological nitrogen in place of inorganic nitrogen in the food production system.

This study aims at developing new way of generating nitrogen supply by biological nitrogen harvesting from the aquatic ecosystems. The birds thrive on feeding on primary consumer such as aquatic isects, creepers, flees and fingerlings. Their droppings known as 'Guano' accumulates in the places, rich in nitrogen, become source of water pollution by adding rich nitrogen in water that cause of eutrophication, a menace for deterioration of water quality and vanishing of water bodies. Water bodies in isolation such as lakes, ponds and wells etc. get infested with such dropping that deteriorate the water quality. The bird droppings so far remained as the source of environmental nuisance. A review of the paths of nitrogen cycle revealed the conventional ways of nitrogen circulation in the nitrogen cycle and there is no visualisation of nitrogen supplementation by the guano. There is no cognizance of this non-conventional source as either a problem for eradication of pollutant or as a resource for making beneficial use. There has been no simple known way to eliminate aquatic bird droppings causing the environmental problems. Thus, there is need to develop ways and means to collect such droppings right at the place where it occurs and lift from the place to eliminate the source of the nuisance on one hand and bring it to make beneficial use on the other. There have been practices of harvesting in other areas such as water harvesting; studied intensively for creating innovative sources of surface runoff collection by specially treating the surface) and also biological water harvesting [7]. This study presents simple ways to totally eradicate the pollutant and make new nonconventional sustainable resource of biological nitrogen from the vast ocean (ocean spread two third against terrestrial one third area of the globe) or any other aquatic ecosystems.

The manuscript comprises review of literature on aspects of greenhouse gas emission, environmental disaster, future demand, regulatory compulsions, and efficient management avenues. The material and method comprises data acquisition for substantiation of potential content and method for biological harvesting by facilitating birds' sitting in night on the trees, on coastal banks, in the boulder zone of rivers and deep water river segments. The results comprise substantiation of potential by using the known data from the reviews, feasibility of biological harvesting measures, quality, and uses of nitrogen in general and of biologically harvested nitrogen in particular. Discussion of results, SWOT (strength, weakness, opportunity and threat) analyses of the present study, conclusion and research needs form the completion of the manuscript.

Review of Literature

Since nitrogen is the major component of primary productivity and occupies all plant and animal cells as amino acid and proteins, tremendous research efforts have gone in productivity front and imbalances in the nitrogen cycle that have environmental disasters [5,6,8,9]. Here effort was made to bring appraisal of the existing situation so that readers get updated with the problems emerging on nitrogen cycle and become appreciative of how non-conventional potential measures come to shoulder the burden and reduce the quantum to the extent possible.

The Nitrogen cycle

The N gets transformed in to various forms as depicted by the nitrogen cycle (Figure 1). The nitrogen gets converted in ammonia NH3 to produce primary productivity of ecosystems. Efficient use of N by meeting crop needs while avoiding excessive applications of N is an important goal [1,4,10]. Among all plant nutrients, N received the most intensive scientific research attention. Nitrogen increases ecosystems productivity and impacting carbon in different forms to make it usable in the ecosystems' primary productivity. The nitrogen cycle revolves around plant productivity and in wake of increased production misbalances are induced that bring environmental disasters [5,6,8,9].

There are two routes for the N to reach from the environment to the terrestrial ecosystems i.e. by microbial fixation bacteria [11] and the thunder and rains (Figure 1). The microbial transformations are organic nitrogen RNO_2, Ammonia NH_3, Ammonium NH_4, Nitrite NO_2, Nitrate NO_3, Nitric acid NO, nitrous oxide N_2O and reformed nitrogen gas N2, that goes back to the atmosphere. With the endeavours of increasing global productivity, the artificial nitrogen is added in addition to the natural build of nitrogen.

In addition to N_2 and NH_3, nitrogen exists in many different forms, including both inorganic (e.g., ammonia, nitrate) and organic (amino and nucleic acids) forms. Nitrogen is one of the main elements in DNA, especially for adenine ($C_5H_5N_5$) and guanine ($C_5H_5N_5O$) [2]. It is necessary component of bio molecules including chlorophyll, proteins and DNA. Nitrogen undergoes many different transformations in the ecosystem, changing from one form to another as organisms use it for growth and in some cases for energy [12,13]. The major transformations of nitrogen are by nitrogen fixation, nitrification, ammonification, denitrification and anammox (Figure 1).

The transformation of nitrogen into its many oxidation stages is key to productivity in the biosphere and highly dependent on the activities of a diverse assemblage of microorganisms such as bacteria, algae and fungi. The health issues include respiratory ailments, heart disease and several cancers. In any situation all the processes continue simultaneously, of course on different organic wastes and so the emission of nitrous oxide is continuous. The N_2O important minor GHG is produced during the formation of nitrite NO_2 (nitrification) and again during reformation of nitrite (denitrification) [14-16]. The flux of release will vary with time and situation of the material under decomposition.

Because the ammonium cation is adsorbed more strongly to soil particles than the nitrate anion, nitrate can flow with water which can be taken up through the roots. Nitrogen is important to microorganisms because certain microbes such as facultative anaerobes use nitrate as terminal electron acceptors. This is especially important in the process of denitrification [17], the conversion of nitrate to atmospheric nitrogen (N_2O/N_2).

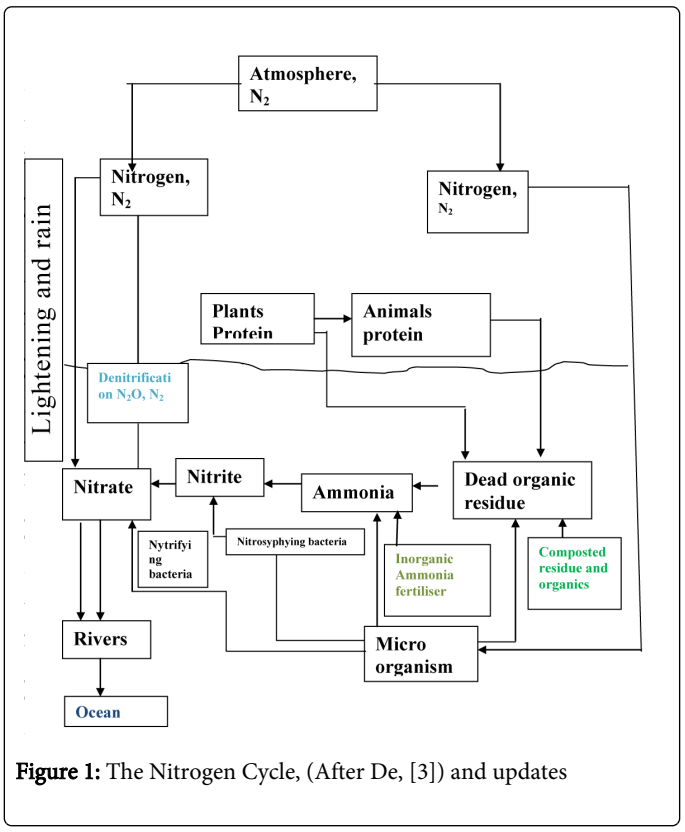

Figure 1: The Nitrogen Cycle, (After De, [3]) and updates

The decomposition of plants and animals also releases organic nitrogen into the soil as ammonia. Bacteria and fungi in the soil then convert this ammonia into ammonium (NH_4), which can be used by plants. Further chemical reactions by *nitrosomonas* bacteria transform the NH_4 into nitrite -NO_2^- .The nitrobacter bacteria then convert the nitrite NO_2- to NO_3- nitrate. This nitrate is very soluble, and used by plants. The cycle is concluded when denitrifying bacteria in soil convert nitrates in anaerobic soil to either nitrogen gas (N_2) or nitrous oxide (N_2O) and these gasses then return to the atmosphere.

Green House gas emission

Study by Yadav presents in detail the environmental pollution and management of nitrogen cycle [4].

Involvement of conversion of NO_3- to N_2 gas in the presence of low oxygen levels

$C_6H_{12}O_6 + 4NO_3^- \rightarrow 6CO_2 + 6H_2O + 2N_2$ (gas) + NO + NO_2 --------- (1)

Bacterial denitrification is the microbial reduction of NO_3- to NO_2- or N. For example *Pseudomonas* use NO_3- instead of O2 as a terminal electron acceptor.

Denitrification is accelerated under anaerobic (flooded or compacted) conditions and high nitrogen inputs. Denitrification results in environmental pollution (destroys ozone) and also contributes to global warming since nitrous oxides do have a minor effect as a greenhouse gas.

Through nitrification and denitrification 10 - 20 % of the applied N is lost.

Anammox: Traditionally, all nitrification was thought to be carried out under aerobic conditions, but recently a new type of ammonia oxidation occurring under anoxic conditions was discovered. Anammox (anaerobic ammonia oxidation) is carried out by prokaryotes belonging to the Planctomycetes phylum of Bacteria. Anammox bacteria oxidize ammonia by using nitrite as the electron acceptor to produce gaseous nitrogen and Anammox bacteria were first discovered in anoxic bioreactors of waste water treatment plants [18], but have since been found in a variety of aquatic systems, including low-oxygen zones of the ocean, coastal and estuarine sediments, mangroves, and freshwater lakes. In some areas of the ocean, the anammox process is considered to be responsible for a significant loss of nitrogen. However, many others argued that denitrification rather than anammox is responsible for most nitrogen loss in other areas. Whether anammox or denitrification is responsible for most nitrogen loss in the ocean, it is clear that anammox represents an important process in the global nitrogen cycle. This fact sheet provides a brief overview of the important components of the N cycle to aid in reaching that goal.

Nitrous oxide-N_2O: Human activities are currently considered to emit 6.7 TgN-N2O per year reported by IPCC, [9] mainly from agriculture which account for 60% of these emissions, but also from other sources such as fossil fuel combustion and industrial processes (0.7TgN per year). So far combustion related nitrogen remediation have been devised. The agricultural sources present considerable challenge [19].

Due to involvement of processes of fixation, ammonification, nitrification denitrification, the use of N in deriving services from different ecosystems, the N cycle gets distorted [20].

Uses of nitrogen

Nitrogen is used for various agriculture and industrial application. Horobin enumerated in detail the uses of various types of nitrogen [21]. Some important and common uses are presented in this study (Table 1). Use of Nitrogen as explosive and azoo dye are very common and widespread applications. The biologically harvested nitrogen application in agriculture and in such areas will be very easy application. Like nitric acid the biologically harvested nitrogen will be useable in dye, explosive, drugs, fertilisers and manufacture of sulphuric acids.

Form of nitrogen	Nature of uses	Product known
Ammonia (NH_3)	Ammonia is used for preparation of urea fertiliser for agriculture	Urea and other nitrogen fertiliser containing compounds are industrially manufactured fertilise.
Ammonium chloride	It is used as flux for soldering and galvanising	
Hydrozone (N_2H_4) and hydrozonic acid (HN_3)	These are highly reacting compound	Used as agricultural fungicides.
Nitrogen tetraoxide (N_2O_4)	Was used as a rocket propeller	The vehicle was used in Apollo moon Program.
Hydrozoic acid $BP(N_3)_2$	Chief use of hydrozoic acid, which is a pressure sensitive compound, is made for explosive detonation.	-
Ammonium nitrate NH_4NO_3	Ammonium nitrate is used as crackers	Crackers are used for amusement at festival and many celebrations.
Nitrous oxide (N_2O), a pollutant and ozone layer depleting agent)	It is used as anaesthesia, but needs purification from Nitric oxide and nitrogen oxide	NO and NO_2 are toxic compounds
Organic Compounds		
Azoo compounds	Used as dye stuff,	Contain double bonded nitrogen
TNT, Trinitrotoluene	With mixture of concentrated nitric acid and sulphuric acid used as aromatic compound	-
N_2 used to provide inert and dry atmosphere	Used as food preservative	Check degradation of chemicals and food in contact with oxygen and water vapour.
In liquid form	Used as low temperature industrial refrigerant.	-
Nitrogen and CO_2	Used in making plastic	-

Table 1: Uses of nitrogen

The disasters of misbalance in the nitrogen cycle

Detailed content on disaster of misbalance of nitrogen cycle was presented by the author in another study [4]. The inferences drawn from the exhaustive study are summarized in Table 2. Since all living organisms and animals including human, depend on nitrogen, the review comprised detailed aspects related to nitrogen cycle. It is evident from the review that as nitrogen is involved in various aspects, there are lot of implications and vast potentials for improvements. The disasters imply that biological nitrogen is getting preference over the inorganic nitrogen fertilisers. The content of the present study deals with a non-conventional and totally new source of the most desirable type of biological nitrogen.

S. No	Aspects under consideration	Worldly suggested solution	Likely challenges on account of operating N cycle
1	Ecological implications of Human alterations to the Nitrogen Cycle	Nitrate leaching, eutrophication, costal and salty lake regions getting shortage of oxygen and reduction in the bio diversity.	It requires expert appraisal and introduction of scientific remedial measures.
2	Future need of food	Food need will increase with the increasing population.	Appropriate technology development is imperative to bring generation II (2G) agriculture.
3	Food consumption and disruption of the nitrogen cycle	Many high sounding policy frame work do focus aspects to be covered	There is lack of appraisal of involvement of scientific principle in the advocated intervention

4	Worldwide Future Fertilizer Consumption	Assessments are formidable	Lot many improvements can be possible by intervention of innovative technologies.
5	Critical consumption trend and implications	Assessment of fertiliser needs and policy are formidable and reactionary	New basis for assessment may bring realistic and manageable scenario.
6	Possible Solutions	Use of animal based manures is sounded.	It requires more scientific thrust to revamp new innovations.
7	Economic and regulatory Incentives	The policy issues focussed on reduction of subsidy on N use only.	It needs to look at the total frame work of policy at national level.
8	Efficient nitrogen Management on the Farm	Provokes low N use efficiency	There are opportunities to enhance the N use efficiency.
9	Critical consumption trends and implications	130 million tonnes of inorganic N may be shortfall in global agriculture	The gravity of this situation can be reduced by innovative management.
10	The Role of Consumers	Consumer's preference has been growing towards organic food which may not be totally ideal. It needs several refinements	Something better than organic should come to fulfil consumption need of not only for some alighted group but for global gentry.

Table 2: Summary of disasters caused by misbalance of nitrogen cycle and likely improvements (Yadav [4])

Materials and Method

Substantiation of nitrogen potential of bird dropping vies a vis other sources.

The exhaustive literature survey revealed existence of valuable data on sources and content of nitrogen, phosphorus and potassium [1]. In this study the data on the compounds where phosphorus is available in the substances were selected to use as supporting and substantiative resource. This study made use of data to substantiate entirely a different issue from which data was published [1]. Thus, in no way it is forfeiting the publisher's copy right; rather it is an extension of long time known data for enhancing its inherent value in furtherance of scientific research. The study demonstrates utility and application, and promotion of very important subject of food and nutrition, ecology and environment and enhancement of resources uses in the global perspective.

Setup for biological nitrogen harvesting

The setups for biological harvesting of phosphorus were developed by the author in the present study to extract the phosphorus from various sites as it naturally occurs.

Collection from trees where birds sit for their night stay: During nights all birds sit on the trees for their night stay. The birds will release droppings intermittently which will fall on the ground. This ground if provided with some litters it will absorb the droppings. The litter can be replaced at convenient regular interval. In place of the litter the ground can be covered to receive the dropping to be collected at regular interval. The ground spread plastic sheet can be sloped to drain in a collection drum so that the droppings get washed in to the drum which can be removed for transferring the nutrient rich water for further processing and use.

Collection from the birds sitting on the aquatic banks and shore: Birds sit collectively or singly on the aquatic banks e.g. river banks, lakes and sea shores. At such strategic points of bird sitting, clusters of stands of 2-3 m lengths, depending on the population strengths, can be erected at some interval, may be 20- 25 m distance along the banks. These stands should have catching tray to receive the droppings and containers (a jerry can) to collect the rain washed liquids. The jerry can should be replaced at some interval.

Collection of bird droppings from the birds sitting on the boulders right in the river course: Birds sit for waiting for long time for catching fish. It is usual to find protruding stones in the streams covered with bird droppings. Such strategic stones can be covered with a plastic cap of white sheet with bottom edge folded in channel form and a bottle attached to it to receive the rain washed substances. The cap and the droppings washed water are removed with another set of empty ones. At such strategic points the clusters of stones may be covered at any time and replaced as per condition and demand. In this sector of collection of phosphate there is scope to utilise knowledge of experienced ornithologist whether at such sites birds will prefer to sit in cluster or to sit alone in isolation. For the cluster sitting some sitting stands of 1 to 1.5m length equipped with dropping catching tray and the collection bottle can be placed at places and checked for collection and replacement as the need be.

Collection from birds flying over deep water segment of aquatic ecosystems: Birds also fly over the deep water section of the aquatic ecosystem to catch fish exposed in the wave action of the flow. In order to facilitate these groups of bird floating raft on the boats can be provided. These rafts will have stand for sitting, tray for catching droppings and collection in the storage jerry cans. These boats once set it can be visited for collection at convenient interval.

In view of the waxy nature of the phosphorus the width of stand for sitting should be in 5-8 cm and below this the dropping catching tray should be located. The surface of the catching tray should be fitted with glass and sloping to drain the liquid substance. The sticky dropping can be scrapped from the glass surface by using wide knife. Thus, four collections set ups become easy and organisable simple setups for biological harvesting of phosphorus from the droppings of birds feeding on the aquatic foods viz the fish fingerlings. These setups can be made from ordinary wooden planks and painted in the colour matching to the surrounding and ground. The setups can be nailed down for stability and transferred to the changed to any strategic sites of bird sitting.

Results

Substantiation of the strength of Nitrogen in Guano

The nitrogen contents: Nitrogen content in the animal ammoniates is in the high range (4-6.5%) in fish followed by that in milogranite (5-6%).Tankage of fish or sheep manure enhances the content to almost double of their respective original nitrogen content.Guano the bird dropping contains nitrogen in the highest range of 10.5 % which at par with the content of meat meal. Among the vetable ammoniates the nitrogen content is maximum in cotton seed followed by that in

castor meal and linseed meal. The nitrogen content in the seed component of vegetable ammoniates is in the highest range in seed and its meal followed by that in the rest part of plant material as revealed by cocoa shell (2.5%). Among the inorganic and manufactured ammoniates the maximum nitrogen content is maximum (45%) in urea followed by (42%) in uramon and (35%) in ammonitrate. Fertiliser containing sulphates have nitrogen content 20.5 %. There is wide variation in nitrogen content in calcium based nitrogen containing fertiliser. The nitrogen content in urea being maximum which is used as top dressing is maximum is subjected ti loss to atmosphere by volatalisation, washoff and leaching etc.

S.No	Compounds	Nitrogen content, percent
Animal ammoniates		
1	Bone meal raw	4-Feb
2	Bone meal steamed	2-Jan
3	Fish (Acid)	4-6.5
4	Fish tankage	6.5-10
5	Guano*	10.5
6	Meat meal	10-11.5
7	Milogranite	6-May
7	Poultry manure(dried)	2.5
8	Sheep manure	2.33
9	Tankage	10-May
Vegetable ammoniates		
10	Castor meal	4.5-. 6.5
11	Cocoa shell	2.5
12	Cotton seed	9-Jun
13	Linseed meal	5
Inorganic and manufactured ammonites		
14	Ammophos (1)	11
15	Ammonium chloride	24
16	Ammonium nitrate	35
17	Ammophos (2)	16
18	Ammoniated superphosphate	5
19	Calcium nitrate	15
20	Cal urea	34
21	Leunaphos	20
22	Leunasalpeter	26
23	Urea	46
24	Uramon	42
25	Sulphate of ammonia	20.5

Table 3: Nitrogen containing compounds*

Magnification of nitrogen in Guano: The sea birds thriving on aquatic primary consumers such as insects, water flee, fingerlings etc produce dropping contains nitrogen 10.5%. The fish contain the maximum nitrogen content as 4-6.5%. In the guano nitrogen magnification occurs from 1.61 -2.2 times that of fish nitrogen content. Thus, biological harvesting of nitrogen by harnessing guano has higher potential than that of fish. The tankages of fish also have magnification in the nitrogen content to the order of 1.6 fold of its original value. Likewise, tankage of sheep manure gets magnified to a level of 2.5 times to original content. These scientific facts support existence of scope for aerobic decomposition of the dropping and dung based manure for reduction in volume for handling the manure.

The quality characteristics of the bird dropping –Guano: The quality of biological nitrogen harvested will be free from any adulteration. Further, analysis of its content will open new avenues for potential applications.

Methods of biological nitrogen harvesting from the bird droppings

The collection setups are simple to facilitate sitting of birds at the banks, right in the river stream protruding boulders in the aquatic ecosystem of the mountainous rivers. Sets of racks mounted on floating boat are also provided for the birds when fly over the deep water segment of aquatic ecosystem for their strategic position to catch their prey. During the day times birds will be coming and moving from place to place in search of their catch. Therefore, simple, transferable, low cost and catch facilitating setups will go long way in harvesting of the droppings of the aquatic birds, the guano, rich in biological nitrogen. The quality of the guano will be pure and free from any adulteration. The special design of the rafts, the droppings catching tray and the glossy surface will facilitate biological harvesting of nitrogen.

The birds sit on the tall trees along the banks for their night stay. Their dropping will be coming throughout the night and get collected in the litter spread to receive it. If the ground is smooth, a thin layer of litter such as wheat straw, grass and paddy straw chaffs or saw dust will be suitable. These materials after collection can be used as soil amendments for nitrogen supplementation in the fields. Use of poultry manure and sheep manure are well known and in practice and guano litter material is similar in handling. The liquid dropping wash off collected from the setups will be directly useable in irrigation water as nitrogen supplement. Research studies are warranted whether the liquid can be used as aerial spray in the way similar to the urea spray for nitrogen supplementation and insect pest control.

Bird dropping based manures

Keeping birds such as poultry and ducks for eggs and meat on terrestrial ecosystem is common practice. The dried poultry droppings contain nitrogen content 2.5 %. The poultry litter becomes environmental problem for the poultry owners on one hand, but it is of high nutritional value for agriculture, on the other. The problem of handling and decomposition becomes a limitation for its easy use. The scientific method of composting is the aerobic decomposition [22]. Further, new method devised for preparing biological charcoal will be

of immense use in boosting organic agriculture and promoting nature agriculture [23].

Inland fishery is practiced on the terrestrial ecosystems by artificial ponds. On such fishery sites the aquatic birds can be reared for harvesting of nitrogen from the waste that generate from such fisheries and keep the environment protected. Thus, rearing of aquatic birds will go long way supplementing on synergic basis and make use of nonconventional natural resources. Ducks are reared on the terrestrial ecosystems which also use aquatic ecosystem, where ever they find, but have not been thought over for their nitrogen harvesting. The droppings of ducks should contain nitrogen more than poultry birds, but of course less than that of guano as ducks subsistence rests on food grains as well. Their litter based manure should find application on line with that of poultry.

Up-scaling of the research for harvesting of iodine from the sea and ocean

Iodine is essential nutrition required in pinch of quantity for daily supplementation for elimination of iodine deficiency in the human health. The iodine is derived from the aquatic ecosystem using the fish. Therefore, further analysis of guano for iodine content will be desirable. There will be some magnification. The biological harvesting of guano will become new potential source of iodine. The vast aquatic ecosystems will enable production of iodine and development of entrepreneurship and employment generation. The coastal areas are used for fish catch by the fish catchers and sometimes there occur boundary disputes. The guano based nitrogen and iodine harvesting will be free from such disputes and international boundary conflicts.

Benefits and potential uses of biologically harvested nitrogen

Areas of application	Existing known Action	Example of application	Supporting References
Enhancement in the aquatic ecosystem services			
Reduction of water pollution at source	Not recognised as serious problem	Reduction of eutrophication in whatever volume it may exist	Hammer Hammer Jr [18]
Wastewater management and utilisation	Recognised but low reliance is observed	Birds will extract the growing fish fingerlings sprawling in the eutrophicated water bodies	Hammer Hammer Jr [18]
Non-dispensable use of aquatic ecosystem			
Utilisation of inland ponds, lakes and rivers fisheries etc	New secondary consumer viz. birds can be reared	New farm on the line of poultry and duckery can be opened for biological nitrogen harvesting	This research
Linking of people, environment and ocean	Coastal areas erected raft and dispensed food to invite birds	Collection from coastal areas	Horobin, [24] and this study
Linking of vast ocean aquatic ecosystem, people and bird kingdom	Entire domain of bird dropping collection covered	Litter collection, raft collection, boat collection and cap collection	This research
Nitrogen and Iodine extraction from the aquatic ecosystems			
Agriculture	Not specific	Biological nitrogen will be in high demand for organic agriculture	Yadav [4,10,23,25]
Medicinal use of iodine	Prospective potential	The biologically harvested refined iodine will be new way of harnessing natural resources.	This study
Nondispensable use of water and indirect use of brackish sea water			
New source of nitrogen and iodine in perspective	In accessible remote inhabiting gentry will be able harness aquatic ecosystems in their vicinity and make use of resources for their agriculture and health.	Agriculture and medicinal uses	This research

Table 4: Benefits and potential applications of biologically harvested nitrogen

The substantiation of the potential of the biological nitrogen over takes limitation of the data collection from the setup devised in the study. The setups are complementing the processes involved in the existence at strategic locations of aquatic birds' movement, sitting during the day and the night time. The birds dropping only during their flying is left, thus, major proportion of bird droppings will be collected. The novel setup facilitates collection without causing disturbance to the birds and ease of collection in wash off form or sticking semi gummy substances from the setup. Thus, the present study shows ways and means of harnessing rare substance from the non-conventional resource, having vast potential for enhancing aquatic ecosystem services with bringing improvement in the ecosystem itself. The guano harvesting does not cause any stress instead, it improvises the environment. It is a real case of linking vast ocean, birds, environment and people dependent on hydro and terrestrial ecosystems.

Discussion

Nitrogen a very important component of plant and animal body exists in atmosphere in four fifth volumes of all atmospheric gases. It is also most important component of food production system and highly researched component of production system. It's different stages taking forms in the nitrogen cycle becomes useful form, easily losing form and environment pollution causing and ozone layer depletion causing agent. In the process of utilization it gets lost in different form that causes misbalance in the nitrogen cycle which causes environmental disaster due to shortage and surplus. Its future demand, scope for management, regulations etc. are covered in this manuscript. This highly demanded product which needs technology for efficient management for enhancing utilization efficiency. Biological nitrogen is always preferable over the inorganic industrial nitrogen product. Biological harvesting of guano is a new sustainable non-conventional source which is un polluted in its quality. It is a source of water pollution. This study shows a new scientific way of harnessing quality biological nitrogen from different strategic places of aquatic ecosystem. Thus, this study adds new route through which nitrogen

can be brought from the aquatic ecosystems to the terrestrial ecosystems. As described in the review there existed only two routes of nitrogen reaching from the atmosphere to the terrain, being microbial nitrogen fixation and by thunder and the rains that brings in the form of nitrates. Thus, biological nitrogen harvesting becomes a third novel way of bringing nitrogen to the terrestrial ecosystem. Further, the third route created in the present study offers vast management potential for enhancing yield and quality, without involvement of risk of environmental pollution and misbalance that causes environmental disasters.

This study enables harness nitrogen by non-dispensable use of water, save the aquatic systems water from pollution and opens scope for up scaling further research for exploring existence of iodine in it. The study also enables devising method of for harnessing the nitrogen and iodine from vast aquatic ocean ecosystem with brackish water quality and linking ocean environment and people for developing enterprise and generating employment. This study also demonstrates way for producing guano from the terrestrial fisheries' farms on the line of poultry and duckery. Method of environmental and water pollution control are devised creating nonconventional sustainable resource. Availability of quality product will enable its users in the remote areas to harness and improve production systems for lively hood. The biological nitrogen harvesting enables linking of aquatic, terrestrial e3cosystems, birds, environment and people for managing production system without causing any stress on the ecosystem. This study opens a new frontier to manage the ecosystem services and improve its quality.

Although quantity of production will not be large at a location, but it will be something where it is not available at all. Nitrogen and iodine content combined will make very profitable avenue. Because it is not involving or demanding extra source of water, it is very refined and classic way of making water use both in poor and good quality. Birds are scavenging agents and their bi-product is made useable product for enhancing good quality product. This study shows and creates global scientific research interests for taking up intensive study on the no consumable natural ecosystems. Thus, a new direction of research, development and making entrepreneurship and employment generation are presented in this study. The biological nitrogen has many potential uses (Table 4). Development of source of terrestrial ecosystem is a form of deriving added source and income from the existing setup with enhanced environment protection, non-dispensable use of water and enhancing production without further risk of environmental disaster.

SWOT Analyses

Swot analyses, a weighting mechanism for evaluating merit of any new development, dealt with regard to this study are given in the following.

Strength

The present research on biological harvesting of nitrogen is substantiated with well documented and academically accepted data; hence it is free from any scientific flaw. The biological harvesting methods are easy to comprehend, visualise, organise and operate for harnessing the N. Thus, the present study presents very good academic, scientific, economic and environmental improvement strength in it. The functioning of the setup for collection operation of biological harvesting is comprehendible and it will work beyond any doubt.

Weakness

There is no scientific weakness. Lack of data collected on the biological nitrogen harvesting get over shadowed by the novelty of research issue and prospects of development. This study will inspire global research interest in the domain of nitrogen, utilisation of ecosystem services. In the due course of time data on biological nitrogen and iodine (in prospects) harvesting will eliminate whatever weakness one may think and make it a highly operational enterprise.

Opportunity

The study opens tremendous opportunity for augmenting supply of biological nitrogen for agriculture and other industrial uses. It opens opportunity for organizing business and employment without dispensation of the existing resources. Thus, it can be called as research producing bonus more than any main business.

Threat

There is no threat or any side adverse effect of application of this research for development.

Action Initiatives

Initiative on global research efforts can be organized with nominal investment of funds. The minimum effort, material and time involved in collecting from the tree sitting of bird can be initiated without any extra setup and costly materials. Such practices do exist for use of poultry farm litter collected droppings. There litter can be aerobically decomposed for further reduction in volume for ease of handling and magnification of nitrogen content. The biological harvesting of nitrogen from other bird sitting strategic locations can be initiated with little involvement of budget and efforts...

Conclusion and Research Needs

The aquatic ecosystem, dependence of birds on fish fingerlings has existed for all times and same was the situation about the bird droppings. This study has brought in a new approach to biologically harvest this bird dropping i.e. guano rich source of nitrogen. Thus, this study enables implementation of method for enhancement of ecosystem services and extension of its uses for development of new enterprises on the inland fisheries and enabling strong linkage between ocean-people and environment. Nondispensable use of water resources suggested in the present study leads to conservation and efficient utilization of primary and secondary natural resources of global as well as local domain.

Further researches are needed to extend study to determine the magnification of iodine (another important nutritional product derived from ocean) content in the guano, simple and effective method of refinements of individual contents of guano as well as development of products of industrial application.

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