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Avifauna Diversity in and Around Kaiga in Uttara Kannada District of Karnataka State

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Key Words: Avifauna, diversity, Kaiga

Abstract

The natural forests of Uttara Kannada district range from evergreen through dry deciduous types. The characteristic species of such forests are *Tectona grandis, Xylia xylocarpa, Terminalia panniculata* and *Meliosma tomentosa*.

The diversity of avifauna was critically studied within an area of 30 km radius of Kaiga in Uttara Kannada during summer season. A total of 55 varieties of birds were encountered in 14 locations during the survey, of which 7.27% were inhabitants of aquatic ecosystems. While most of the types of birds were arboreal in habit, cattle egret was recorded as most dominant species (28.75 %), followed by house crow (12.55 %), little egret (9.42 %) and jungle crow (8.71 %). In terms of species richness, Kaiga was very rich with 19 species of birds followed by Chendiya and Yellapur with 17 species each. Majority of the birds were omnivorous in habit preferring insects, worms and arachnids as their principal food (36.52 %) items followed by frugivorous and granivorous birds comprising 12.1 and 11.8 % respectively.

Shannon-Weiner diversity index and evenness index values for the encountered birds were estimated to be 3.90 and 0.67 respectively, indicating better environment and rich diversity of the avifauna.

Introduction

Avifauna is an important component of the terrestrial and aquatic ecosystems and useful to the human beings in various ways. Their study is the vital step to understand the process of natural habitats.

The states of Karnataka consist of four geographically distinct regions, viz. coastal, malnad, northern maidan and southern maidan; with peculiar climates of their own. Coastal region of the state consists the districts of Uttara Kannada (North Kanara) and Dakshin Kannada (South Kanara). The natural vegetation of Uttara Kannada district ranges from evergreen through dry deciduous type (Prasad *et al.* 1985), while about 85 % of the forest area has been stock-mapped under deciduous type. The characteristic species of this type is *Tectona grandis,* and often it is mixed with *Xylia xylocarpa, Terminalia panniculata* and *Meliosma tomentosa.*

The existing habitats in and around Kaiga of the Uttara Kannada district appear to be favourable for the growth and propagation of avifauna. In addition to two units (1&2), which are under construction, the nuclear power corporation of India has proposed to set up four additional units (3, 4, 5, and 6) of 235 MW each based on pressurized heavy water reactor system at Kaiga. The area within 10 km is predominantly a forestland with dense growth of trees and vegetation. While about 85% of the area within 10 km comprised of forestland, around 9, 4 & 2 % of the area come under the water spread area of Kadra reservoir, agricultural field and barren land respectively. There is a wildlife sanctuary near Dandeli at a radial distance of 47 Km away from the site. In order to evaluate the impact of the proposed nuclear power plant on the surrounding environment, baseline studies towards monitoring of birds and their diversity at different locations surrounding the nuclear power station near Karwar, were undertaken and presented in this communication.

Uttara Kannada, with 60% of its land area covered by forests, harbouring 1741 species of flowering plants, is not only the most forested district of the Western Ghats but also harbours the most diverse avifauna. A total of 403 taxa of birds were reported over the century from this district, of which, 300 were terrestrial birds extensively using the forests (Daniels *et al.* 1991 and Gadgil 1992). It is believed that the bird fauna has changed little over the past century in spite of many changes in land use (Daniels *et al.* 1990).

Materials and Methods

Field data were collected during summer in different locations, viz. Kaiga, Kadra, Bhaire, Kodsalli, Ramanguli, Anshi, Kodalgadde, Gopshitta, Chendiya, Amadalli, Asgur, Mastikatte, Ankola and Yellapur (Fig.1) within 30 km radius from Kaiga in Uttara Kannada district. Roadside count of birds was made as per the standard procedures after traversing a given distance within which designated sampling areas occurred (Richter and Sondgerath 1990 and Clarke 1986). The millimeter of the vehicle was used to measure the stretch of study area. Birds were studied by direct observation with the help of 8 x 30 'Super Zenith' binocular and were identified by adopting available literature (Ali 1988 and Ali and Ripley 1983). The species list was prepared by walking through the area, listing taxonomic position of each species encountered, relative abundance and absolute number in each specific area. The data were subjected to detailed analysis. The dominance index, census index, Shannon-Wiener diversity index and evenness index were derived from the available data (Kotangale and Ghosh 1997).

Feeding habit of the birds was assessed on the basis of food items preferences, as recorded by Ali and Ripley 1987. Altogether 12 groups of food items, preferred by the avifauna, were demarcated from the literature. Depending on the feeding habit, each species of bird was placed in respective group. While a species opting 2 or more groups of food items, due weightage was given to each type of food and percentage of birds preferring different food items have been derived (Kotangale and Ghosh 1997).

Results and Discussion

A total of 55 birds, mostly the arboreal, were encountered during the present study, of which, 7.27 % were aquatic birds (Table 1). Cattle egret was found to be most dominant species (28.75%) followed by house crow (12.55%), little egret (9.24%), and jungle crow (8.71%). It has been observed that water birds were less in number probably due to scarcity of water in the study area. Shannon-Wiener diversity index and evenness index value for the encountered birds were 3.90 and 0.67 respectively, indicating better environment of the study area.

While vultures were not encountered during the present study, other scavengers recorded in the areas were house crow, jungle crow, pariah kite and common myna. The dominant and subdominant birds in the different localities are presented in Table 2. Common peafowl, an endangered bird was recorded as most dominant species in Anshi village. While dominance of jungle crow over other birds was exhibited in maximum (28%) study areas, the species did not emerge as subdominant in remaining areas. Census index for the total population in the study area ranged from 19/ km^2 at Kodalgadde to 64/ km^2 at Kadra and Bhaire (Table 2).

The birds encountered in the study area were further grouped on the basis of their habits preferring different type of foods. It revealed that the majority of the birds in the study area were insectivorous in habit preferring insects, worms and arachnids as their foods (36.5%) followed by frugivorous birds attracted on fruits, berries and buds (12.1%) and granivorous (11.8%) (Fig. 2). The importance of insects as the food in bird's life is very essential for their existence. Though some birds are strictly herbivorous in habit, animal food is of vital importance for their breeding and egg laying. Many species of tropical birds are said to be partly or wholly frugivorous, but on closer examination a few proved to be totally dependent on the plant food, while others are only facultative frugivores, foraging insects as an essential supplement to the protein which they cannot obtain from fruits (Snow and Snow 1971 and Foster 1978). This is especially true during the breeding season when protein becomes crucial to the successful raising of the young ones (Levey 1988). Female's reproductive success depends mostly on her access to proteinaceous food while male's on the access to female (White 1988). Very young birds of some species are compelled to eat the equivalent of more than half their own weight in food per day in order to satisfy their metabolic requirements and keep warm. Thus, most vegetarian species give their young at least a partially insectivorous diet during the early stages of growth (Parker and Haswell 1963). In view of such metabolic requirements, insectivorous birds were found in large number in the study area.

The birds, like other animals, also get affected by environmental pollution and therefore serve as bio-indicators. Earlier reports had shown that the roosting sites of birds and their population were adversely affected by human population pressure due to rapid urbanization and industrialization (Bhattacharjee and Hazarika 1985) as well as human disturbance and increased illumination (Sandhu and Dang 1980). Construction of nuclear power plants in association with the development of township in Kaiga may lead to have similar impacts on avifauna.

Table 1. Census of avifauna in the study area, Karwar, Karnataka

Sl No.	Common Name	Scientific Name	Dominance Index	Census Index (no./Km^2)
1.	Pond heron	*Ardeola grayii*	03.67	02.625
2.	Cattle egret	*Bubulcus ibis*	28.75	20.625
3.	Little egret	*Egretta garzetta*	09.42	06.750
4.	Blackwinged kite	*Elanus caeruleus*	00.17	00.125
5.	Pariah kite	*Milvus migrans govinda*	00.17	00.125
6.	Sparrow-hawk	*Accipiter nisus*	00.35	00.250
7.	Crested hawk eagle	*Spizaetus cirrhatus*	00.17	00.125
8.	Greyheaded fishing eagle	*Ichthyophaga ichthyaetus*	00.17	00.125
9.	Crested serpent eagle	*Spilornis cheela*	00.17	00.125
10.	Painted spurfowl	*Galloperdix lunulata*	00.17	00.125
11.	Common peafowl	*Pavo cristatus*	00.52	00.375
12.	Whitebreasted waterhen	*Amaurornis phoenicurus*	00.17	00.125
13.	Bronzewinged jacana	*Metopidius indicus*	00.35	00.250
14.	Blue rock pigeon	*Columba livia*	02.80	02.000
15.	Spotted dove	*Streptopelia chinensis*	01.22	00.875
16.	Little brown dove	*Streptopelia senegalensis*	00.17	00.125
17.	Roseringed parakeet	*Psittacula krameri*	00.17	00.125
18	Coucal	*Centropus sinensis*	00.17	00.125
19	Pied kingfisher	*Ceryle rudis*	00.17	00.125
20.	Whitebreasted kingfisher	*Halcyon smyrnensis*	02.45	01.750
21.	Small green bee-eater	*Merops orientalis*	04.90	03.500
22.	Indian roller	*Coracias benghalensis*	00.17	00.125
23.	Hoopoe	*Upupa epops*	00.17	00.125
24.	Malabar pied hornbill	*Anthracoceros coronatus*	02.97	02.125
25.	Pigmy woodpeacker	*Picoides nanus*	00.35	00.250
26.	Indian pitta	*Pitta brachyura*	00.17	00.125
27.	Grey shrike	*Lanius excubitor*	00.17	00.125
28.	Baybacked shrike	*Lanius vittatus*	00.17	00.125
29.	Rufousbacked shrike	*Lanius schach*	00.17	00.125
30	Golden oriole	*Oriolus oriolus*	00.17	00.125
31.	Blackheaded oriole	*Oriolus xanthornus*	00.17	00.125
32.	Black drongo	*Dicrurus adsimilis*	02.62	01.875
33.	Whitebellied drongo	*Dicrurus caerulescens*	00.17	00.125
34.	Racket-tailed drongo	*Dicrurus paradiseus*	00.52	00.375
35.	Greyheaded myna	*Sturnus malabaricus*	00.70	00.500
36.	Pied myna	*Sturnus contra*	00.17	00.125
37.	Common myna	*Acridotheres tristis*	05.05	03.625
38.	Jungle myna	*Acridotheres fuscus*	00.17	00.125
39.	House crow	*Corvus splendens*	12.55	09.000
40.	Jungle crow	*Corvus macrorhynchus*	08.71	06.250
41.	Pied flycatcher shrike	*Hemipus picatus*	01.05	00.750
42.	Common wood shrike	*Tephrodornis pondicerianus*	00.17	00.125
43.	Scarlet minivet	*Pericrocotus flammeus*	00.35	00.250
44.	Redwhiskered bulbul	*Pycnonotus jocosus*	00.17	00.125
45.	Whitecheeked bulbul	*Pycnonotus leucogenys*	00.17	00.125
46.	Redvented bulbul	*Pycnonotus cafer*	01.05	00.750
47.	Jungle babbler	*Turdoides striatus*	00.17	00.125
48.	Orphean warbler	*Sylvia hortensis*	01.93	01.375
49.	Magpie robin	*Copsychus saularis*	01.57	01.125
50.	Indian robin	*Saxicoloides fulicata*	00.17	00.125
51.	Thickbilled flowerpecker	*Dicaeum agile*	00.35	00.250
52.	Tickell's flowerpecker	*Dicaeum erythrorhynchos*	00.52	00.375
53.	Purple sunbird	*Nactarinia asiatica*	00.17	00.125
54.	House sparrow	*Passer domesticus*	00.35	00.250
55.	Whitebacked munia	*Lonchura striata*	00.17	00.125

In general, wide varieties of avifauna were recorded in the study area around Kaiga. In order to improve the avifaunal diversity, which is likely to be affected due to anthropogenic activities in the region, emphasis should be given towards the habitat improvement. Recently, constructing a dam on Kali River close to the power plant has made a large reservoir. This will attract the birds preferring wetland habitats. In view of ecological changes, a database on avifauna needs to be generated during post commissioning phase of the nuclear power plant. The forests in this area have a potential for developing apiculture, which further needs to be systematically developed, alongwith the development of minor forests as suggested by Gadgil *et al.* ,1987. The water bodies in the study area should also be stocked with fast growing commercial fishes to utilize the fish culture potential of the surrounding waters.

Acknowledgements

The authors express their sincere sense of gratitude to the Head, Environmental Biotechnology Division, NEERI, Nagpur for his constant encouragement. The facilities provided by the Director, NEERI are also gratefully acknowledged.

Table 2. Dominance and Census of avifauna at different sites within the study area

Sr. No.	Site	Dominant		Subdominant		Census index for total population (no/ Km^2)
		Species	Index	Species	Index	
1.	Kaiga	Orphean warbler	26.00	Magpie robin	09.18	52.00
2	Kadra	Jungle crow	45.55	House crow	15.91	64.00
3	Bhaire	House crow	31.97	Cattle egret	21.31	64.00
4	Kodsalli	House sparrow	29.43	House crow	17.72	57.00
5	Ramanguli	Malabar pied hornbill	35.87	Little brown dove	14.27	58.00
6	Anshi	Common peafowl	25.07	Malabar pied hornbill & Scarlet minivet	16.62 (each)	35.00
7	Kodalgadde	Jungle crow	22.74	Black drongo & Jungle babbler	13.72 (each)	19.00
8	Gopshitta	Cattle egret	41.50	Little egret & Pond heron	10.45 (each)	33.50
9	Chendiya	Cattle egret	41.49	House crow	22.13	61.40
10	Amadalli	Jungle babbler	18.10	Little egret, Pond heron & White breasted kingfisher	13.65 (each)	35.00
11.	Asgur	Small green bee-eater	23.84	House sparrow	14.24	36.00
12	Mastikatte	Jungle crow & Roseringed parakeet	11.96 (each)	Little brown dove & Redvented bulbul	08.36 (each)	29.00
13	Ankola	Cattle egret	52.77	House sparrow & Little egret	10.50 (each)	56.80
14	Yellapur	Jungle crow	28.31	Blue rock pigeon	15.06	56.50

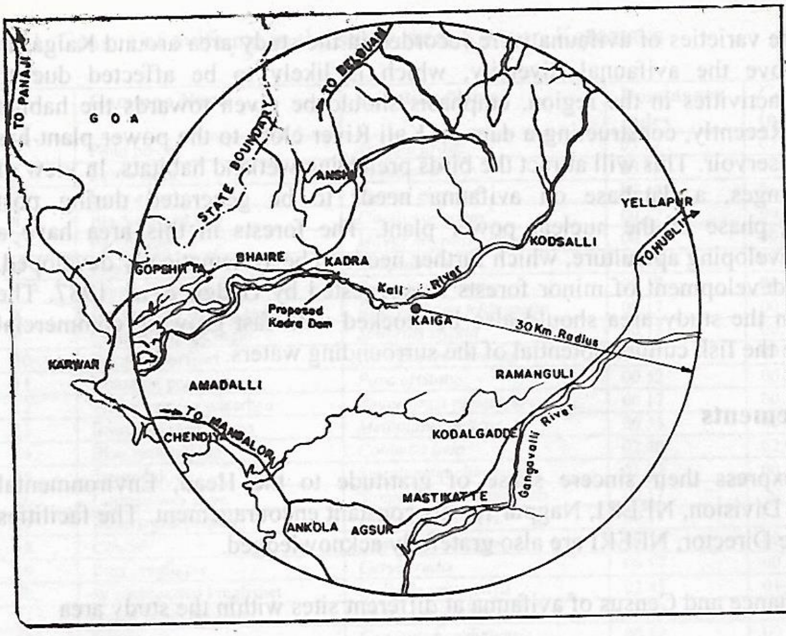

Fig. 1: Map showing different locations near Karwar for survey of Avifauna

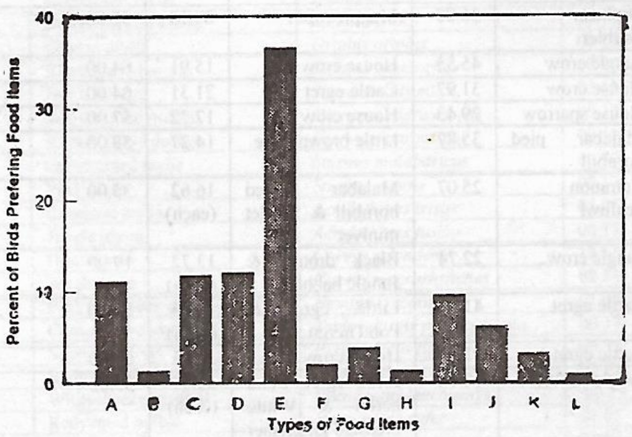

Fig. 2: Performance of food items by avifauna recorded at Kaiga (Legends A- Flower nectar, B- Vegetable shoot & Roots, C- Grains & Seeds, D- Fruits, Berries, & Buds, E- Insects, Worms & Arachnids, F- Fish, G- Frog & Tadpole, H- Molluscs, Crabs & Crustaceans, I- Small reptiles & Small mammals, J- Birds, their eggs & young ones. K- Garbage & Kitchen scrap, L- Offal & carrion)

References

Ali, S. 1988. *The book of Indian Birds*. Oxford University Press, Mumbai

Ali, S. and Ripley, D. S. 1983. *A Pictorial Guide to the Birds of the Indian Subcontinent*. Oxford University Press, Mumbai

Ali, S. and. Ripley, D. S. 1987. *Compact Handbook of the Birds of the India and Pakistan*. Oxford University Press, Delhi

Bhattacharjee, P.C. and Hazarika, B. C. 1985. Roosting sites and roosting birds at Gauhati Municipal Area. In: *Second International Symposium on Life Sciences. Nov. 14-16, 1985*, NEHU, Shillong

Clarke, R. 1986. *The handbook of Ecological Monitoring: A GEMS/ UNEP Publication*. Clarendon Press, Oxford.

Daniels, R. J., R. Hegde, M. and Gadgil, M. 1990. Birds of the man-made ecosystems : The plantations. *Proc. Indian Acad. Sci. (Animal Sci.)* **99(9), 79-89.**

Daniels, R. J., R. Hegde, M., Joshi, N. V. and Gadgil, M. 1991. Assigning conservation value : A case study from India. *Conservation Biology*. **5(4), 464-475.**

Foster, M. S. 1978. Total frugivory in tropical passerines: A reappraisal. *Trop. Ecol*. **19, 131-154.**

Gadgil, M. 1992. Conservating biodiversity as if people matter: A case study from India. *Ambio*. **21, 266-270.**

Gadgil, M., Hegde, K. M. and Shetty Bhoja, K. A. 1987. Uttara Kannada : A case study in hill area development. In: C.J. Saldanha (ed.) *Karnataka – State of Environment Report 1985-1986*. Centre for Taxonomic Studies. **155-172.**

Kotangale, J. P. and Ghosh, T. K. 1997. Diversity of avifauna in and around Ranapratapsagar, Rajasthan. *Encology*. **12 (3), 29-37.**

Levey, D. J. 1988. Spatial and temporal variation in Costa Rican fruit and fruit-eating bird abundance. *Ecol. Monogr*. **58, 251-269.**

Parker, T. J. and Haswell W. A. 1963. *A Text Book of Zoology*. Vol II. Seventh Edition. Macmillian & Co. Ltd., London.

Prasad, S. N., Hegde, M. S., Gadgil, M. and Hegde, K. M. 1985; An experiment in Eco-development in Uttara Kannda District of Karnataka. *South Asian Anthropologist*. **6(1), 73-83.**

Richter, O. and Sondgerath, D. 1990. *Parameter Estimation in Ecology*. VCH Verlagsgesellschaft, Weinheim.

Sandhu, P. S. and Dang, H. R. 1980. Roosting behaviour of parakeets in relation to human disturbance. In: *Second All India Symposium on Life Sciences*. March 9-11. Institute of Science, Nagpur.

Snow, B. K. and Snow, D. W. 1971. The feeding ecology of tanagers and honeycreepers in Trinidad. *Auk*. **88, 291-322.**

White, T. C. R. 1993. *The Inadequate Environment – Nitrogen and the Abundance of Animals*. Springer-Verlag Berlin Heidelberg.

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Larvivorous Behaviour of *Channa Gachua* on Filaria Vector – A Biological Control Measure

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Key Words: Channa gachua,Culex quinquefasciatus,Vector

Abstract

Mosquitoes are known to transit many diseases like malaria, filarial, Japanese encephalitis, yellow fever and dengue. In India alone approximately 40 million people suffer from mosquito borne diseases annually. Insecticides play a major role in vector control programmes and continue to be a major component for integrated vector management. But due to the health hazards associated with the use of chemical insecticides new biological control measures are being tried in the last few years. Use of predatory fishes is one of the major components of biological vector control so as to minimize vector borne diseases.

The present paper is an attempt to present the findings of a study on predatory behaviour of locally available edible fish *Channa gachua* on *Culex quinquefasciatus* a known vector for *Wouchereria bancrofti*. Maximum predation was found to 190 larvae per day. It was observed that fish prefer second instar larvae.

Introduction

With the introduction of *Gambusia affinis* biological control of mosquitoes has been recently practiced in fresh water bodies. Besides predatory fishes water bugs of family Napidae, Bellostomatedae and Notonectidae have also been tried in the past few years (as reported by Ravishankar 1985, Singh *et al.* 1989, Venkatesan 1985 and Saxena *et al* 1995). Jayshree and Panickar 1992 have reported the use of predatory fishes against mosquito vectors. Similarly, Prasad and Sharma 1994 have reported the control of rural malaria through bioenvironmental control measures.

Looking to the present need of searching an indigenous biological control measure to control the vectors, present study has been made to test the predaceous efficacy of a major carp *Channa gachua* an indigenous fish locally available in fresh water pond of Betul District of Madhya Pradesh (India).

Materials and Methods

Fish fauna survey of locally available fishes was done before starting the study. During the survey 34 species of indigenous fishes were identified from different habitats. For the present study, fish *Channa gachua* was selected on the basis of individuals' potential and its edible nature. Gill net method was used to catch the fishes and an aquarium of size 54x30x30 cm was used to acclimatise the fishes. The fishes were acclimatized for one-month period in laboratory under controlled conditions. Mosquito larvae were cultured in a ware kept reared in the laboratory so as to get the desired age larvae for experimental purpose. First to fourth instar larvae of *Culex quinquefasciatus* were used for the present study from the laboratory cultured stock.

Three sets of experiments for the predatory study of *Channa gachua* were setup in the laboratory as per the following details.

1. First set consists 5 to 10 adult specimens of *Channa gachua* in 20 litres of pond water with standard fish food.
2. Second set consists same number of fishes as set-1 without fish food.
3. The third set was control having same number of fishes with pond water

The experiments were performed in three replicates with 50 larvae of each instar separately. Observations were recorded on 24 hourly basis.

Results and Discussion

The results of all experiments are shown in Table 1 and 2. Predatory performance of fishes with artificial food is shown in Fig.1. It is quite apparent from the results that the rate of predation is high when fishes were kept in an aquarium without fish food as shown in Table 2. Maximum predation was found to 190/ day/ individual for second star larvae. This is perhaps a considerable behaviour of an indigenous fish reported so far. Saxena *et al.* 1995 notified *Mystus cavacious* as maximum predator of mosquito larvae followed by *Rasbora daniconius* but the author has reported there premium predatory performance, which could not be compared with 24 hours predatory behaviour, noticed in the present study. Results showed that predatory performance of fish decreases with the increase of age of prey. It indicates that predatory performance of *Channa gachua* has a negative co-relationship with the age of prey. It was also found that with the increase of predator number in an ecosystem, the predatory performance decreases. Results also showed that without fish food predatory performance is better than with fish food as without fish food predation was found to be 190/day/ individual against with fish food of 100/day/individual.

The results of predatory performance test on *Culex quinqefasciatus* are found quite interesting and further needs to be performed under field conditions. Jayshree and Panicker 1992 investigated 34 indigenous fishes for larvaevorous potential and found that *Mystus cupanus* has highest potential. Therefore, indigenous fishes could be used as better tool for biological control of mosquitoes, as also stressed by Prasad and Sharma 1994.

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Authors are thankful to Professor S. K. Jain, Principal S.S.L. Jain College, Vidisha for laboratory facilities and to Dr. S. S. Katare, Principal, J.H. Govt. College, Betul for permission to carry out research work.

Table 1. Predatory Efficiency of Fishes with artificial food

Fish Name	Number of Fishes	Predation of instar larvae	Larvae fed/ day
Channa gachua	1	II III IV	100 90 75
Channa gachua	2	II III IV	180 160 140
Channa gachua	3	II III IV	245 225 195
Channa gachua	4	II III IV	300 280 248

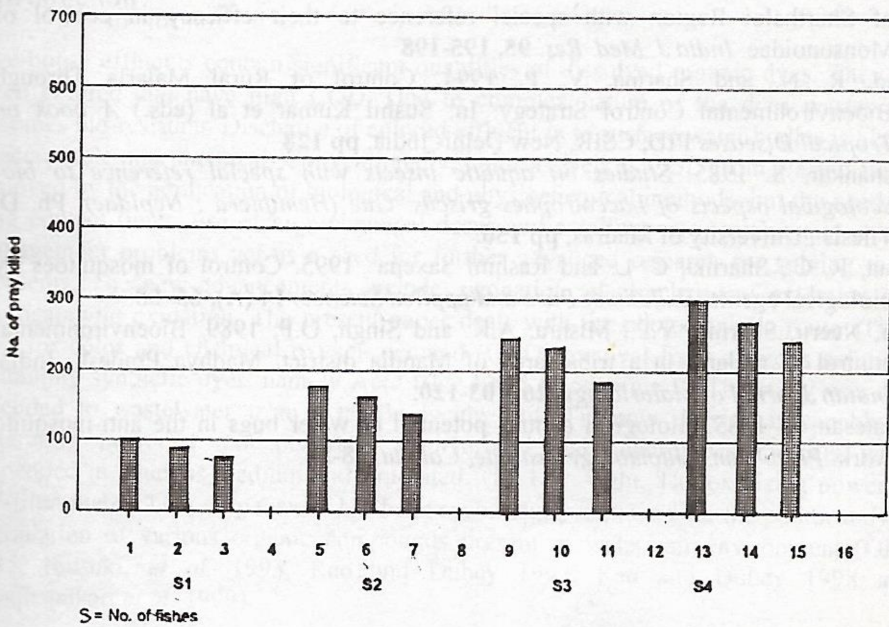

Fig. 1: Predatory performance of fishes *Channa gachua* with artificial food

Table 2. Predatory Efficiency of Fishes without artificial food

Fish Name	Number of Fishes	Predation of instar larvae	Larvae fed/ day
Channa gachua	1	II III IV	190 160 150
Channa gachua	2	II III IV	350 300 250
Channa gachua	3	II III IV	500 425 360
Channa gachua	4	II III IV	620 540 460

References

Jayshree, M and Panicker K. N. 1992. Larvivorous potential of some indigeneous fishes of Sharthaloi Region with special reference to their efficacy in control of Monsonoidae. *India J. Med. Res.* **95, 195-198**

Prasad, R. N. and Sharma, V. P. 1994. Control of Rural Malaria Through Bioenvironmental Control Strategy. In: Sushil Kumar et al (eds.) *A book on Tropical Diseases* PID, CSIR, New Delhi- India. **pp 128**

Ravishankar, S. 1985. *Studies on aquatic insects with special reference to bio-ecological aspects of Laccotrophes griscus. Gue (Hemiptera : Nepidae).* Ph. D. Thesis ,University of Madras, **pp 156.**

Saxena, R. C., Sharma, C. L. and Rashmi Saxena 1995. Control of mosquitoes by biological agents. *Bulletin of Pure and applied Science.* **14 (A), 65–68.**

Singh, Neeru, Sharma, V.P., Mishra, A.K. and Singh, O.P. 1989. Bioenvironmental control of malaria in a tribal area of Mandla district, Madhya Pradesh, India. *Indian Journal of Malariology.* **26, 103-120.**

Venkatesan, P. 1985. Biological control potential of water bugs in the anti-mosquito work. *Proc. Sem. Entomology Institute, Calicut,* 78-83.

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Photocatalytic Route for Reduction of Color and Chemical Oxygen Demand from Dye-Containing Wastewater

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Key Words: Photocatalysis, Color, COD Removal

Abstract

The color and chemical oxygen demand arising from Acid Blue I, Rhodamine B and textile industry wastewater containing vinyl sulphone-based reactive dye are treated using TiO_2/ UV technique. Color is found to be removed substantially during first one hour of irradiation of Acid Blue I and Rhodamine B systems. The rate of color removal from textile dyeing industry wastewater in an order of magnitude lower than that of Acid Blue I and Rhodamine B. Simultaneously, the overall COD removal efficiencies under aerated condition are found to be 60% for Acid Blue I/ TiO_2 in 2 hours, 90 % for Rhodamine B/TiO_2 in 4-5 hours and 45 % for wastewater/ TiO_2 in $3^1/_2$ hours. The supplied air is found to enhance rate of color and COD removals. The results suggested that some stable intermediates are formed during phoooxidation of these dyes and the photocatalytic degradation of reactive dye containing wastewater is relatively slower.

Introduction

Dye-house effluents contain significant quantities of dissolved organic dyes. They are often colored and have high COD. Due to complex nature of the dyes wastewater becomes bio-resistant. Discharge of colored effluent in to surface water bodies is highly unacceptable and unethical. Conventionally, color as well as COD from wastewater is removed by the application of biological and physiochemical methods, but the need for long contact times, use of high chemical doses and entailing regeneration and sludge management problems act as a seed for further advanced research for solving these problems. The new advancements include, ozonation, electrochemical oxidation and photocatalytic oxidation. The present paper deals with the photocatalytic route (TiO_2/ UV) for color and chemical oxygen demand (COD) removal from aqueous solutions containing synthetic dyes, namely Acid Blue I and Rhodamine B. The study was also extended to wastewater from a textile-dyeing unit. Titanium dioxide is capable of generating powerful oxidants such as hydroxyl and superoxides radicals when suspended in aqueous medium and irradiated with UV light. The oxidizing power of UV-illuminated TiO_2 suspensions has been successfully exploited for the photocatalytic degradation of various organic compounds present in water/ air environment (Ollis 1985, Ibusuki, *et al.* 1993, Rao and Dubey 1997, Rao and Dubey 1998 and Dhodhapakar, *et al.* 1999).

Materials and Methods

Titanium dioxide (TiO_2) used in the experimentation was obtained from British Drug House (BDH, Mumbai). The TiO_2 is pure anatase with mean particle size of 0.34 μm. The dyes used were:

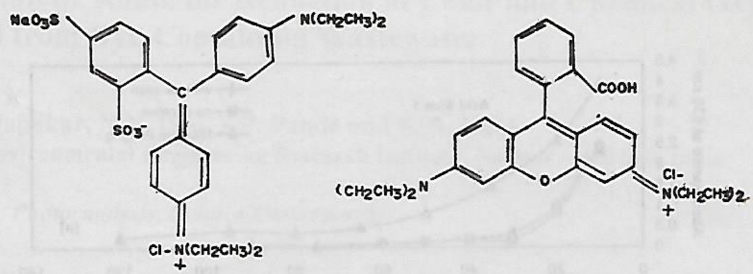
1. Acid Blue I (commercial name –Patent Blue VS) supplied by Amar Dye Chem Ltd. Kalyan
2. Basic Violet 10 (commercial name – Rhodamine B) procured from E.Merck (Germany)

Both the dyes contain the same chromophoric group i.e. p-quinoid (Structure is shown in Fig. 1). However, Acid Blue I is acidic whereas Rhodamine B is basic in nature. Distilled water was used for preparing aqueous solutions of appropriate concentration of these dyes. In addition, textile industrial wastewater containing vinyl sulfone based Remazol type dye was also used.

A typical photooxidation experiment includes exposing the aqueous dye solution containing a certain amount of TiO_2 catalyst powder in suspension to UV light. The catalyst containing dye solution was taken in to 500 ml capacity glass reactor and a 125 W high-pressure Hg-arc lamp housed in a borosilicate thimble was inserted into the reactor. Cold water was circulated through borosilicate sleeve in order to control excessive heating of reaction liquid from lamp source. The reaction mixture was magnetically stirred throughout the experiment. The experiments were conducted both in the absence and presence of externally supplied air. Air was bubbled using an aquarium pump. Samples of color and COD determination were collected periodically. Prior to these determinations, the catalyst powder was removed from the aqueous samples by filtering through membrane filter (0.22 μm). Spectrophotometeric measurements were carried out in the range of 200 – 700 nm using double beam Perkin Elmer λ 900 Spectrophometer. The reduction in the color band intensity was determined from the time-overlaid spectra. On the other hand, diminution in COD was also determined following standard procedure, APHA-AWWA-WPCF 1989.

Results and Discussion

The UV-VIS absorption spectra for Acid Blue I, Rhodamine B and wastewater from textile dyeing unit are shown in Fig.2. The decrease in the intensity of the color band of Acid Blue I (λ_{max} = 638 nm, ε = 0.59 x 10^{-5} M^{-1}), Rhodamine B ((λ_{max} = 551 nm, ε = 0.89 x 10^{-5} M^{-1}) and textile dyeing unit wastewater ((λ_{max} = 661 nm) is depicted in Fig. 3 a-c. The influence of aerating the suspensions on the color band reduction is also. illustrated in these figures. The color of these dyes quickly decreased during the first 1-hour irradiation period under phtocatalytic conditions. The initial rate of color removal (in absorption units, a.u.) in each case was deduced from linear regression and R^2>0.9 is regarded as indication of best fit. The initial rate of color reduction for the case of Acid Blue I is 0.107 a.u./ min (with aeration) and 0.106 a.u./ min (without aeration)



Acid Blue I　　　　Rhodamine B

Fig. 1: Structure of Acid Blue I and Rhodamine

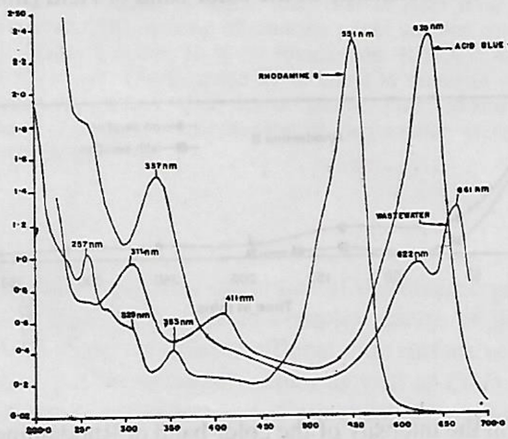
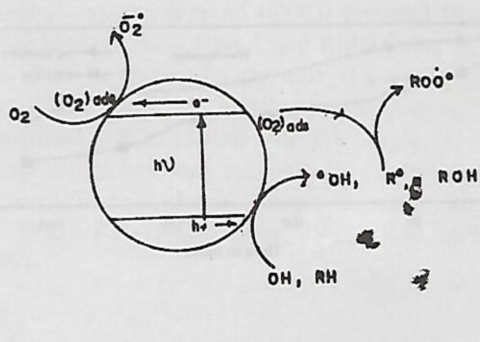


Fig. 2: UV – VIS absorption spectra of Acid Blue I, Rhodamine B and Textile dyeing unit wastewater



Scheme 1: Tentative pathway showing participation of oxygen, formation of hydroxyl and organo - radicals

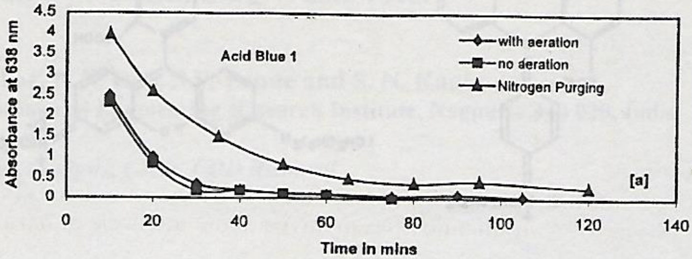


Fig. 3 (a): Decrease in the intensity of the color band of Acid Blue I at 638 nm

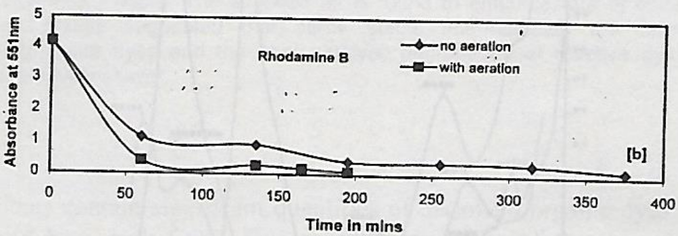


Fig. 3 (b): Decrease in the intensity of the color band of Rhodamine B at 551 nm

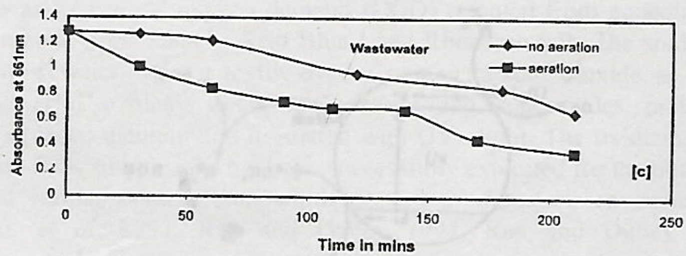


Fig. 3 (c): Decrease in the intensity of the color band of Textile dyeing unit wastewater at 661 nm

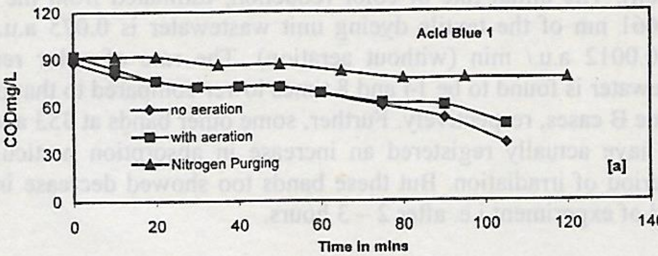


Fig. 4 (a): COD reduction from Acid Blue I

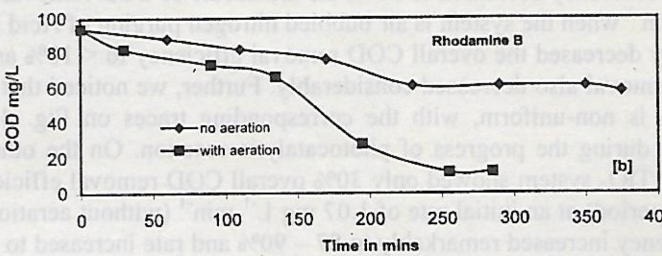


Fig. 4 (b): COD reduction from Rhodamine B

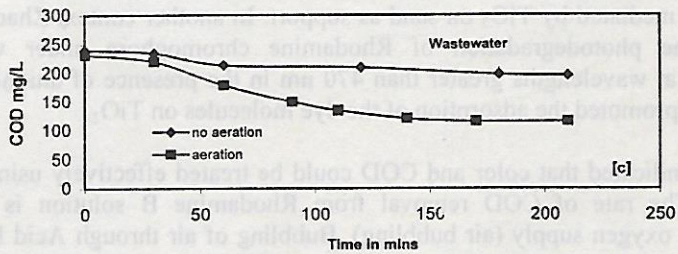


Fig. 4 (c): COD reduction from Textile dyeing unit wastewater and for the case of Rhodamine B, it is 0.06 a.u./ min (with aeration) and 0.05 a.u./min (without aeration). The initial rate of color reduction, estimated from the decrease of color band at 661 nm of the textile dyeing unit wastewater is 0.075 a.u./ min (with aeration) and 0.0012 a.u./ min (without aeration). The rate of color removal from industrial wastewater is found to be 14 and 8 times lower compared to that of Acid Blue I and Rhodamine B cases, respectively. Further, some other bands at 353 and 329 nm of Rhodamine B have actually registered an increase in absorption particularly during intermediate period of irradiation. But these bands too showed decrease in absorption towards the end of experiment i.e. after 2 – 3 hours.

Fig. 4 (a – c) depict the removal of COD from Acid Blue – I and Rhodamine B containing solutions as well as textile dyeing industry wastewater under the photocatalytic conditions. These figures illustrate the effect of aeration on the COD removal kinetics also. The Acid Blue I / TiO_2 system has shown 60% overall COD removal efficiency without external supply of oxygen during 2 hours irradiation period. The initial rate of COD removal in this case is 0.60-mg $L^{-1}min^{-1}$ Although, the overall COD removal efficiency decreased to 50%, the initial rate of COD removal increased to 0.68 mg L^{-1} min^{-1} when the system is air bubbled nitrogen purging of Acid Blue I/ TiO_2 system actually decreased the overall COD removal efficiency to < 10% and the initial rate of COD removal also decreased considerably. Further, we noticed that the trend of COD removal is non-uniform, with the corresponding traces on Fig. 4a exhibiting plateau region during the progress of photocatalytic reaction. On the other hand, the Rhodamine B/ TiO_2 system showed only 30% overall COD removal efficiency (during 4^{th} irradiation period) at an initial rate of 1.07 mg L^{-1} min^{-1} (without aeration). With the aeration efficiency increased remarkably to 87 – 90% and rate increased to 0.195 mg L^{-1} min^{-1} Textile dye-waste/ TiO_2 system showed an overall COD efficiency of 45 – 50 % during 3 ½ hour irradiation period, with an initial rate of 0.43 mg L^{-1} min^{-1} (without aeration) and 0.96 mg L^{-1} min^{-1} (with aeration). Once again the trend of COD removal is non-uniform and the corresponding plot showed plateau towards the end of the reaction period. In relation to our studies, Matthews, 1991 reported on the transformation of Rhodamine B its partial mineralization under artificial UV light and sunlight UV mediated by TiO_2 on sand as support. In another context Zhao *et al.* 1998 examined the photodegradation of Rhodamine chromophore under visible light illumination at wavelengths greater than 470 nm in the presence of anionic surfactant that actually promoted the adsorption of the dye molecules on TiO_2.

The results indicated that color and COD could be treated effectively using TiO_2/ UV technique. The rate of COD removal from Rhodamine B solution is remarkably enhanced by oxygen supply (air bubbling). Bubbling of air through Acid Blue I/ TiO_2 system resulted in only moderate increase in COD removal rate. Although same chromophoric group , p- quinoid is present in both the dyes, the difference in color removal rates between Acid Blue – I and Rhodamine B cases can be attributed to the other structural dissimilarities between these dyes. The Acid Blue I dye molecule contains $SO3^{-}$ Na^{+} group and Rhodamine B has – COOH group. The position of these groups in the dye molecules could substantially influence adsorption of these dyes on

TiO_2. Particularly in view of the initial pH which is 4.9 for Rhodamine B system and 6.7 for Acid Blue I system, the adsorption of Acid Blue dye is more preferred. The -COOH group is a poorer functionality for adsorption. Indeed, Rhodamine B adsorbed very less (2-5%) on TiO_2 catalyst. Further, the observed rise in absorption of 411 and 311 nm bands in Acid Blue I and 441, 353 and 329 nm bands in Rhodamine B during the photocatalytic experiments may be due to the formation of some intermediates with their absorption overlapping with that of the native dye molecules.

The present study revealed that the oxygen supply favorably affects the COD removal efficiency for Acid Blue I and Rhodamine B with TiO_2. This finding is also supported by previous studies made by Rao and Dubey 1997, Schwitzgebel *et al.* 1995 and Kesselman *et al.* 1994. Molecular oxygen has been shown to scavange photoelectrons transforming it self into superoxide radicals (Schwitzgebel *et al.*, 1995). The superoxide radicals participate in the oxidation of organic molecules in addition to the photogenerated hydroxyl radicals. This process appears to play a major role in enhancing the COD removal from Rhodamine B/ TiO_2 system. Since the state of affair until photogeneration of hydroxyl radicals and photoelectron scavenging by molecular oxygen is the same in both the cases, some stable intermediates may have formed during the reaction of COD removal from these systems due to which the corresponding plots displayed plateaus. The tentative pathway showing the participation of oxygen is shown in Scheme –I. Oxygen scavenges photoelectrons that accumulate at conduction band and form superoxide radicals. The photogenerated holes (h^+) and / or hydroxyl radicals at valence band react with organic molecules (RH) and generate organo radicals (R^*). The absorbed oxygen and freshly formed organo radicals on the surface readily react to give organoperoxy radicals (ROO^*) opening up oxygen mediated route of photooxidation. Alternatively, the superoxide radicals could also cause substantial oxidation of dye molecules.

Conclusion

The color and COD in wastewater imparted by the dissolved organic dyes can be treated using TiO_2/ UV technique. Both Acid Blue I and Rhodamine B showed dissimilar color reduction kinetics although the same chromophoric group, p-quinoid is present in both the dyes. Although COD can be removed from both Acid Blue I/ TiO_2 and Rhodamine B/ TiO_2 systems, the rate of removal of COD from the latter is remarkably enhanced by external oxygen supply. Finally, The TiO_2/ UV technique may also be applied to treat color and COD from the textile dyeing unit waste water.

Acknowledgements

The authors are grateful to Dr. R. N. Singh, Director, NEERI for granting permission to submit this work.

References

APHA-AWWA-WPCF 1989. *Standard Methods for the Examination of Water and Wastewater* 17th edition. American Ppublic Health Association, Washington, D.C.

Dhodapakar, R. S., Rao, N. N., Pande, S. P., and Kaul, S. N. 1999. Photocatalytic destruction of organic pollutants in water.In: *Advances in Wastewater Treatment*. Tech. Sci. Publications. **pp 451**.

Ibusuki Kutsuna, S. Takeuchi, K., Shin Kali K., Sasamoto, T. and Miyamoto, M. 1993. Removal of low concentration air pollutants through photoassisted heterogeneous catalysis. In: D. F. Ollis and H. Al-Ekabi (eds) *Photocatalytic Purification and Treatment of Water and Air.*, Elsvier, Amsterdam, **pp. 375-386**.

Kesselman, J. M., Shreve, G. A., Hoffman, M. R. and Lewis, N. S. 1994. Flux matching conditions at TiO_2 photoelectrodes : Is interfacial electron transfer to O_2 rate limiting in TiO_2 – Catalyzed photochemical degradation of organics. *J. Phys. Chem.*, **98, 13385-13395**.

Matthews, R. W. 1991. Photooxidative degradation of colored organics in water using supported catalysts. TiO_2 on sand. *Water Res.* **25, 1169-1177**.

Ollis, D. F. 1985. Contaminant degradation in water – Heterogenous photocatalysis degrades halogenated hydrocarbon contaminants. *Environ. Sci. Technol,* **19, 480**.

Rao, N. N. and Dubey, S. 1997. TiO_2 catalyzed photodegradation of reactive Orange 84 and Alizarin red S biological stain. *Ind. J. Chem. Technol.* **4, 1-6**.

Rao, N. N. and Dubey, S. 1998. Photocatalytic degradation of reactive Orange 84 in dye house effluent using single pass reactor. *Studies in surf. Sci. and Catalysis.* **113, 1045-1050**.

Schwitzgebel, J, Ekerdt, J. G., Gerischer, H. and Heller, A. 1995. Role of the oxygen molecule and of the photogenerated electron in TiO_2 photocatalysed air oxidation reactions. *J. Phys. Chem,* **99, 5633-5638**.

Tinuchi, L., Borgarello, E., Minero, C. and Pelizetti, E. 1993. Treatment of industrial wastewater by photocatalytic oxidation on TiO_2. In: D. F. Ollis and H. Al-Ekabi, (Eds) *Photocatalytic Purification and Treatment of Water and Air.* Elsevier Amsterdm pp. **585-594**.

Zhao, J., Taixing Wu, Kaiqun Wu, Oikawa, K., Hidaka, H. and Serpone, N. 1998. Photoassisted degradation of dye pollutants 3 degradation of the cation dye Rhodamine B in aqueous anionic surfactants/ TiO_2 dispersions under visible light irradiation: Evidence for the need of substrate adsorption on TiO_2 particles. *Environ. Sci. Technol.* **32, 2394**.

NEWS of Interest

Onsite Waste Treatment Technology

A Supercritical Treatment Method developed by Ishikawajima Harima Heavy Industries Co and Shinryo Corp (both Japan) enables the organic garbage component of wastes to be reduced carbon dioxide and water. The equipment, priced in the range of $ 500,000 - $ 900,000, separates organic material from other wastes by sieving and compressing. This organic waste is then crushed in to particles less than 1 mm. The groung garbage is mixed with water and liquefied in a reactor at about 300 °C and 100 bars. The pressure is then reduced to about 10 bars and air is blown into the reactor to decompose the garbage by air oxidation at 170 – 200 °C. The operating cost, as per company officials, will be around 100,000 $ / annum for a system that can treat 1 MT/ day.

Chemical Engineering, Jan 2000, Chemical Industry Digest, Jan-Feb 2000

Rules to Curb Ozone-eating Gases

The Union Environment Ministry has come up with comprehensive rules to regulate the phasing out of ozone-depleting substances (ODS) over the next decade or so, bringing, India in line with its International obligations.

The ozone Depleting Substances (Regulation and Control) Rules, 2000, seek to ensure a step-wise elimination of ODS, regulating production, trade, import and export. Ozone-eating gases are used in the manufacture of aerosol cans, such as perfumes, and foam products as well as refrigeration, air-conditioning and fire fighting among other things.

The planned phase-out dates are :

- Chlorofurocarbons (CFCs) may not be used in manufacture beyond January 2003, except for medical purposes and metered dose inhalers for which affordable replacements are not readily available.
- Use of Halons is generally prohibited after January 2001.
- Methyl Bromide, used in limited quantities for pre-shipment and quarantine, may be used till January 2015 – this is used in India mainly for fumigation during dockyard storage.
- Hydrochloroflurocarbons may be used till 2040.

The rules specify compulsory registration of ODS producers, manufacturers of ODS based products, importers, exporters and stockiest. They will be required to maintain records and file periodic reports on production and use of ODS. Among other regulatory steps, licenses will be needed for all imports and exports of ODS and products containing ODS.

The Times of India, Date 07/08/ 2000

The Hazardous Wastes (Management and Handling) Amendment Rules, 2000

The above rules notified by Ministry of Environment and Forests, Government of India have not only made the scope of hazardous wastes extremely comprehensive in terms of definitions of hazardous wastes but have also added ***stringent provisions*** in the existing the Hazardous Waste (Management and Handling), 1989.

The changes incorporated in the amendment rules, 2000 require a great deal of action from all parties involved in the life cycle of hazardous wastes i.e.

- ***Generator*** of the hazardous wastes: Occupier
- ***Transporter*** of the hazardous waste
- ***Operator*** of the facility, where the waste is destined for treatment and final disposal

The key provisions of the rules come into force w.e.f 6th January 2000.

Abstract of the Provisions is given hereunder.

New Definitions of Hazardous Wastes

In the context of these rules hazardous wastes are those waste substances, which are listed in Schedule I, II and III. ***Please note that the Schedule I of the Hazardous Wastes (Management and Handling), Rules 1989 now stand withdrawn/ repealed.***

Schedule I: Process specific Hazardous Wastes

Schedule I lists 44 type of industrial process and the waste streams being generated from these processes. Any industrial Activity, which involves any of these 44 processes and generate the kind of waste stream listed in this schedule (irrespective of the quantity of generation) shall fall in the preview of these rules.

Schedule II: Non Process Specific Hazardous Wastes

Schedule II lists five classes of waste substances (namely class A, B, C, D and E) along with concentration limits. Any industrial activity/ process/ operation, generating any of the type of waste substance listed in these five waste classes equal to or more than the concentration limits specified in the corresponding class of this schedule shall be treated as hazardous waste.

Schedule III: Lists of Waste to be Applicable only for Imports and Exports

This schedule lists waste substances, which are regulated under these rules, incase, occupier is involved in the import and exports of these waste(s).

Liability for Proper Handling and Disposal

The occupier as well as operator the facility have been made responsible for the proper collection, reception, storage and disposal of hazardous wastes listed in schedule I, II and III., so as to ensure no adverse effects on the environment.

Duties of Occupier and Operator of a Facility

Both have an obligation to contain contaminants, prevent and limit consequences of adverse effects on human beings/ environment as well as provide information, training and equipment to persons working on the site.

Fee for Processing Application of Authorization

Occupier is required to submit the application for authorization alongwith a sum of Rupees Seven Thousand Five Hundred towards processing; and analysis fee, if required.

Time Limit for Processing Application of Authorization

State Pollution Control Boards (SPCBs) to process the application for authorization within 90 days of the receipt of such application.

Time Frame for Authorization

Under these rules, the grant of the authorization shall be in force for a period of five years from the date of issue or renewal.

Conditions for the Renewal of the Authorization

SPCB shall renew the authorization based on

i. Submission of annual returns by the occupier
ii. Efforts undertaken for reduction/ recycling or reuse of the hazardous waste.
iii. Compliance with prescribed authorization conditions
iv. Remittance of the processing fee.

Manifest System

These rules introduce a system of waste tracking in the form of "Manifest System". The system warrants occupier to provide specific information to the transporter operator of the facility and State Pollution Control Board. Occupier is also required to provide transporter the Transport Emergency Card (TREM) regarding the nature of the waste and measures to be taken during emergency.

Identification of Disposal Sites

The new rules prescribe the responsibility for the site identification for disposal of hazardous wastes on occupier or operator of the facility. However, in case of common hazardous waste disposal site, the State Government, operator of the facility or any association of occupiers has been made responsible for identification of such sites. *"Public Hearing"* has been made mandatory for notification of such sites as hazardous disposal sites in both the cases i.e. individual or common sites.

Design and Setting up of Disposal Facility

The new rules prescribe the mandatory approval for the design and layout of the proposed facility from the concerned SPCB, before setting up of such facility.

Liability of the Occupier, Transporter and Operator

This is the most significant provision that has been added in these rules. According to this provision occupier and operator of the facility are liable to reinstate or restore damaged or destroyed elements of the environment.

The SPCBs have been empowered to levy the fine in case of any violation of these rules, however, with the approval of the Central Pollution Control Board.

The above information is based on the Environmental Legislation Update, Issue 06 (January – March 2000)

Other particulars related to theses rules like details of Schedules, etc. will be published in the next issue.

The Manufacture, Storage and Import of Hazardous Chemicals (Amendment) Rules, 2000

The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000 has been notified by the Ministry of Environment and Forests, New Delhi on 19th January 2000. They have come in force from the same date. These Amended Rules have primarily widened the scope of chemicals that now shall be categorized as "Hazardous Chemicals" in addition to defining certain terms used in The Manufacture, Storage and Import of Hazardous Chemical Rules, 1989 and addressing the deficiencies in the threshold limits.

The above information is based on the Environmental Legislation Update, Issue 06 (January – March 2000)

Other particulars related to theses rules will be published in the next issue.

The Noise Pollution (Regulation and Control) Rules, 2000

Ministry of Environment and Forests, New Delhi has notified the above rules, which have come into force w.e.f. 14th February 2000.

The key provisions of these rules are:

- Ambient air quality standards in respect of noise for different areas/ zones have been notified in the schedule of these rules.
- State Governments made responsible to categories the areas in above zones and take measures for abatement of noise pollution and to ensure compliance with the ambient air quality standards in respect of noise.
- Restriction on the use of loud speakers/ public addressing system subject to certain conditions.
- A person may make a complaint to the designated "Authority" in case of the actual noise level exceeds the ambient noise standards by 10 dB(A) or more as compared to the prescribed standards.
- Designated Authority to take action against the violator in accordance with the provisions of these rules/ other law in force.

The above information is based on the Environmental Legislation Update, Issue 06 (January – March 2000)

Details will be published in the next issue.

Setting up of an Hazardous Waste Management Facility in Thane – Belapur Industrial Area

The Maharashtra Government had initiated a programme to set up a hazardous waste management facility with the assistance of World Bank. Seven sites were identified for hazardous waste disposal in different industrial zones of the state, including Trans Thane Creek (TTC) Industrial Area, Navi Mumbai.

As per the reports 7 hectares of area situated in TTC Industrial Area was identified for setting up this facility.

The Maharashtra Government had appointed M/s Chemcontrol A/S of Denmark in association with their Indian Counterpart M/s Econ Pollution Control Pvt. Ltd. for preparing Techno Economic Feasibility study and Environmental Impact Assessment for hazardous waste disposal in TTC area. The consultant had prepared the report and the same was accepted by the Central Government and will be implemented soon.

Chemical Industry Digest, Jan- Feb 2000.

Environment Conservation Journal 1 (1): 27-39, 2000

Environmental Impact of Fertilizer Production, its Use and Role of EIA in Sustainable Fertilizer and Agriculture Development

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Key Words: Fertilizer, Effluent Quality, EIA, Impact

Abstract

The paper presents a critical appraisal of the environmental pollution problems arising due to the production and use of nitrogenous and phosphatic fertilizers. The paper also highlights their impact on various components of environment and role of environmental impact assessment in sustainable fertilizer and agricultural development.

Introduction

India accounts for 2.25 % of the global land and 16 % of the world population. The population of India is estimated to reach billion marks by 2000 AD, which require larger and larger quantities of food grains (Khanna *et el.* 1989). Fertilizer industry has been playing a crucial role in ensuring sustained growth of agriculture production to meet the food grain requirement of 240 million tones by the end of 2000 AD. India is the largest manufacturer of fertilizers in the world. Installed capacity of nitrogenous fertilizers in India has increased from 0.085 million tone in 1950-51 to 9.3 million tone in 1995-96. The overall per hectare consumption has been rising steadily and is now reached a level of 70 kg from a mere 0.55 kg in 1950-51. Total consumption of fertilizer has increased from 0.069 million tone in 1950-51 to a level of 13.84 million tone in 1996 and has resulted in increase in the production of food grains from 55.9 million tone in 1949-50 to 190.0 million tone in 1995-96 (Narayan, 1990, India Fertilizer Industry 1995,India 1995, Aggarwal 1996). With sustained growth and systematic development of irrigation, irrigated potential has increased from 22.0 million hectare during pre plan period to about 81.2 million hectare at the end of 1991-92 (India 1995). Fertilizer consumption in India is about 70 kg per hectare against world average of 170 kg/hectare and 300 kg/hectare in developed countries (Awasthi 1997). Fertilizer consumption per capita per hectare is shown in Fig. 1.

The production of nitrogenous and phosphatic fertilizer in 1995-96 was 8.78 and 2.58 million tones respectively. By 2000 AD the estimated nitrogenous fertilizer requirement will be about 12.75 million tones and the estimated production will be 12.45 million tones with estimated demand supply gap of 0.3-1.9 million tones (Aggarwal 1996).

In view of the high yielding variety of seeds requiring abundant various nutrients, in the form of fertilizers, in order to realize their genetic potential during short vegetation period; fertilizer production and consumption in India has increased substantially. Fertilizer and agricultural development scenario in India is shown in Fig. 2.

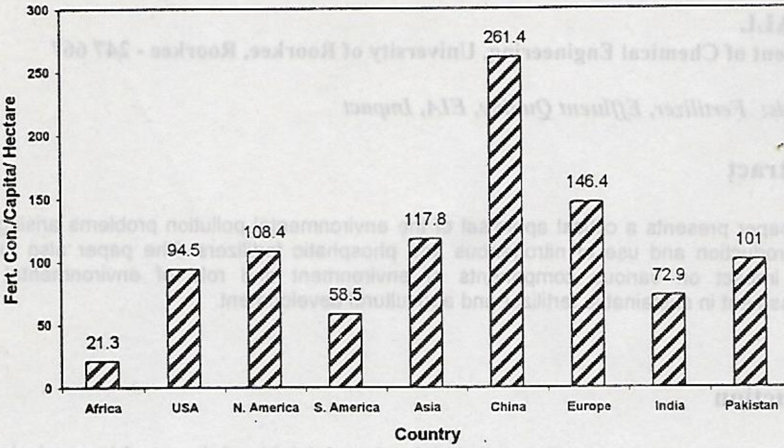

Fig. 1: Fertilizer consumption per capita per hectare land (in Kg)

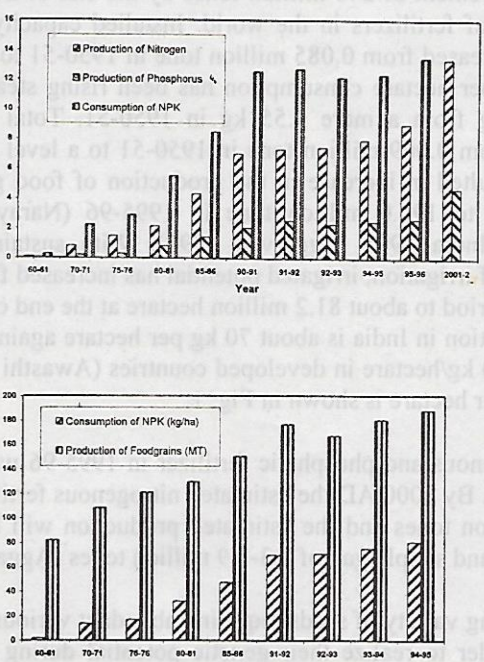

Fig. 2: Fertilizer and agriculture development scenario in India

Fertilizer industry consume wide variety of raw materials, like - natural gas, naphtha, coal, lignite, fuel oil, rock phosphate, gypsum, sulphur etc., for the production of wide spectrum of nitrogenous, phosphatic and mixed fertilizers. Utilisation of huge amount of natural resources and production of various grades of fertilizers raises a number of environmental issues and the fertilizer industry has been classified as one of the top highly polluting industries in India. Therefore, environmental impact assessment has been made mandatory.

About 40 million tones of P_2O_5 and 30 million tones of sulphur are used annually for the production of phosphatic fertilizer in the world (Landge and Ranade 1995). Consumption of rock phosphate, sulphur and imported phosphoric acid in India is about 2.1, 0.550 and 0.130 million tones respectively. In India production of phosphatic fertilizers has increased from 0.011 million tones in 1950-51 to 2.49 million tones in 1994-95 and consumption has increased from a level of 0.001 million tones to 2.95 million tones. There are about 80 units producing phosphatic fertilizers.

All activities, during extraction and storage of raw materials, manufacturing of the nitrogenous and phosphatic fertilizers and their use, contribute significantly to the pollution load on the environment by releasing huge amount pollutants like - ammonia, fluorine, fluorides, nitrate, phosphate, chromium, nickel, cadmium, arsenic, selenium, mercury, uranium, oil & grease, suspended solid, SOx, NOx, fly ash and other particulate matter etc. About 150 million tone of phosphogypsum is being produced annually, which is highly contaminating, and for that reason phosphatic fertilizer industries are posing serious environmental problems all over the world (Landge and Ranade 1995). Phosphogypsum to the tune of 4-5 million tones per annum is produced in India from phosphoric acid plants and an inventory of about 8-9 million tones is already available (CBRI Technology Profile 1993).

Thus, fertilizer industries have to play a crucial role for sustainable development that can be achieved through a sound environmental management plan, resource conservation, environmental equity, and maintenance of human health and Eco system structure. Fertilizer use efficiency has to be increased through better agronomic approaches. Present paper highlights the environmental issues related to fertilizer production and its use, their impact on various environmental components along with the steps required for sustainable fertilizer and agricultural development.

Environmental Pollution due to Fertilizer Production and Use

Environmental Impact Due to Off- Plant Activities

Nitrogenous and phosphatic fertilizer plant consumes wide variety of raw materials. Several thousand tones of natural resource are being consumed every year. Extraction of huge natural resource and subsequent stage of processing, transport of these raw materials raises number environmental issues. Extraction of oil and subsequent processing and mining of coal, lignite, limestone, rock phosphate results in solid wastes (around 3-4 times of raw materials) during mining. Apart from this, the workers are also exposed to dust and suspended particulates. The mining of these materials also have an impact on the ecosystem.

Environmental Impact of In-plant Activities

Significant quantities of liquid, gaseous and solid wastes are generated during the manufacturing of various grades of fertilizers. Other factors causing environmental deterioration within plant are thermal stresses and noise pollution. Waste water, air pollutants, solid waste generated in a fertilizer complex and their impact on environment are given in Fig. 3, 4 and 5 (Gomma and Lablanc 1985, Mahajan 1985, Barnes *et al.* 1987).

Water Environment

During the manufacture of various types of fertilizers related chemicals and intermediates, wastewater of varying qualities and quantities are generated depending upon the sections of the plant. It may be seen that almost all components present in the wastewater can have direct or indirect impact on the receiving water stream. The contaminants are well above the tolerance limits prescribed by MINAS in many cases. Main constituents in the wastewater from nitrogenous and phosphatic fertilizer plants are carbon particles, oil, sulphur compounds, arsenic, nickel, ammonia, cyanide, phenol, phosphates, fluorides etc. These pollutants have severe impact both on the surface and ground water.

Air Environment

Major gaseous pollutants from fertilizer plants are ammonia, sulphur bearing compounds, oxides of nitrogen, CO, acid mists, particulates at various stages of operation, fluorine, SOx, NOx and CO from power plants. Significant amount of NOx is emitted from nitric acid units in many nitrogenous fertilizer plants. Some of the parameters which increases tail gas NOx emissions in nitric acid plants are insufficient air supply resulting in incomplete oxidation, low pressure in absorber, high temperature in cooler, condenser and absorber, production of excessively high strength acid and operation at high throughput. The air quality deterioration may affect health and well-beings of people residing in the plant vicinity. This may also cause damage to the crop and vegetation in the surrounding agricultural areas.

During the transient conditions (start up condition, process upset conditions due to tripping, shut down condition) in ammonia and urea plant gases containing CH_4, CO, CO_2, H_2 and traces of ammonia from various sections are let out to atmosphere in appreciable quantities. Accidental leakages from ammonia storage and supply sections may be due to failure of couplings and hoses, leaks from pipes, gasket and appurtenances and rupture of lines, due to move of tank cars & trucks carrying ammonia. Phosphatic fertilizer also produces large-scale air pollution due to emission of dust and toxic gases at various stages of operation. Fluorine emission is one of the

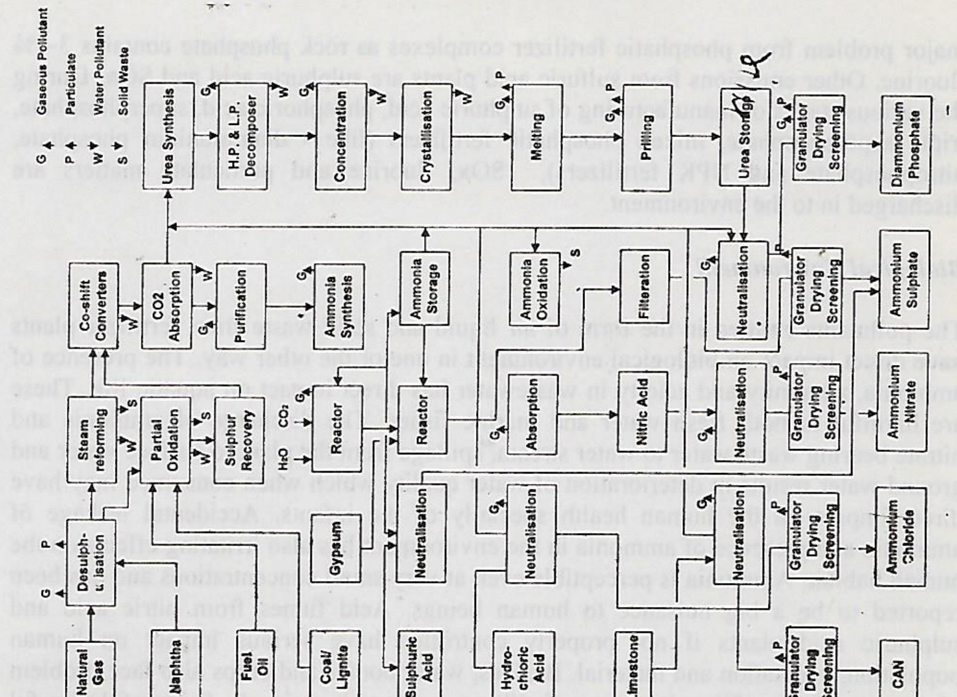

Fig. 3: Waste emission and generation in nitrogeneous fertilizer plant

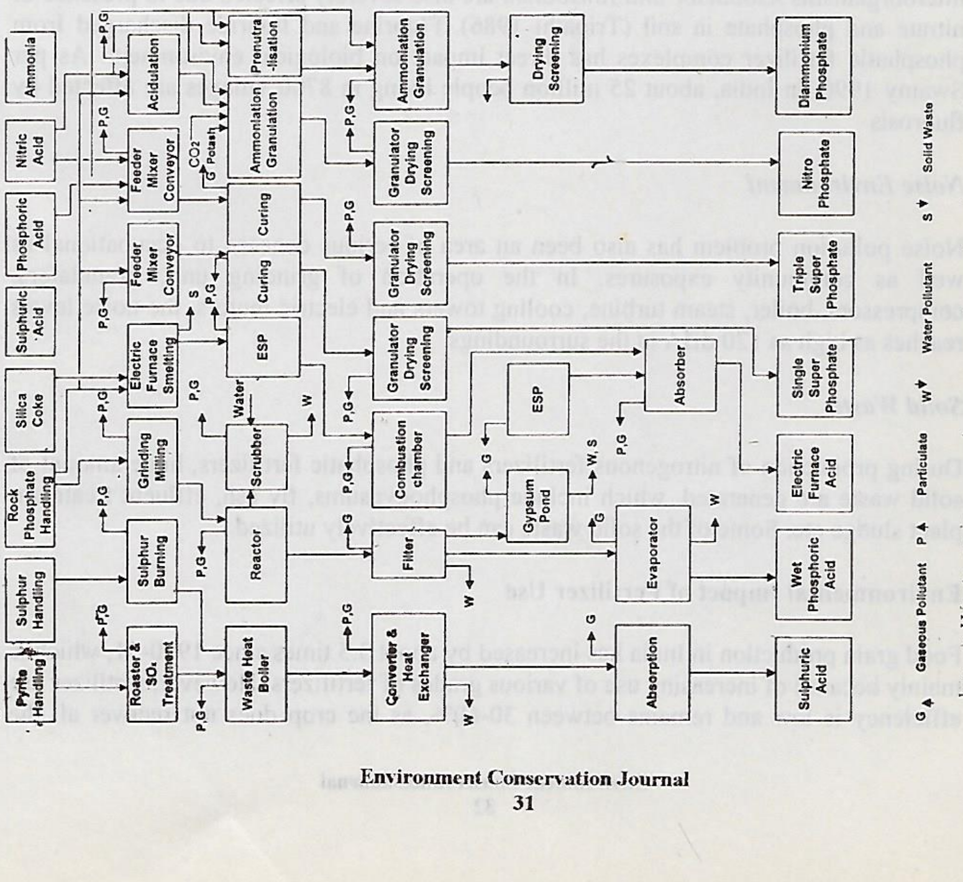

Fig 4: Waste emission and generation from phosphate fertilizer plant

major problem from phosphatic fertilizer complexes as rock phosphate contains 3-4% fluorine. Other emissions from sulfuric acid plants are sulphuric acid and SOx. During the various stages of manufacturing of sulphuric acid, phosphoric acid, superphosphate, triple superphosphate, mixed phosphatic fertilizers (like - diammonium phosphate, nitrophosphate and NPK fertilizers), SOx, fluorine and particulate matters are discharged in to the environment.

Biological Environment

The pollutants emitted in the form of air liquid and solid waste from fertilizer plants have direct impact on biological environment in one or the other way. The presence of ammonia, alkalinity and acidity in wastewater has direct impact on aquatic life. These are harmful to both fresh water and marine fishes. The discharge of ammonia and nitrate bearing waste water to water stream, spillage from the plant to surface water and ground water results in deterioration of water quality which when consumed may have direct impact on the human health specially of the infants. Accidental leakage of ammonia and presence of ammonia in the environment has also irritating effects on the human habitat. Ammonia is perceptible even at very small concentrations and has been reported to be a big nuisance to human beings. Acid fumes from nitric acid and sulphuric acid plants if not properly controlled have serious impact on human population, vegetation and material. Besides, water bodies and crops also face problem of nitrate pollution if the nitrogenous fertilizers are used luxuriously. Some of the useful microorganisms *Azobactor and Rhizobium* are also severely affected due to presence of nitrate and phosphate in soil (Tripathi 1986). Fluorine and fluoride discharged from phosphatic fertilizer complexes has direct impact on biological environment. As per Swamy 1990, in India, about 25 million people living in 8700 villages are affected by fluorosis

Noise Environment

Noise pollution problem has also been an area of serious concern to occupational as well as community exposures. In the operation of grinding unit, granulators, compressors, boiler, steam turbine, cooling towers and electric motors, the noise levels reaches as high as 120 dBA in the surroundings.

Solid Waste

During production of nitrogenous fertilizers and phosphatic fertilizers, huge amount of solid waste are generated, which include phosphogypsums, fly ash, effluent treatment plant sludge etc. Some of the solid waste can be effectively utilized.

Environmental Impact of Fertilizer Use

Food grain production in India has increased by about 3.5 times since 1950-51, which is mainly because of increasing use of various grades of fertilizers. However, fertilizer use efficiency is low and remains between 30-60%, as the crop does not recover all the nitrogen applied to the field. With proper irrigation facilities, better water management and proper fertilizer selection; the fertilizer use efficiency has increased during recent years. However, it is still at a lower level. Important environmental issues related to the use of nitrogenous and phosphatic fertilizer are the increase in phosphate, nitrate, heavy metal content of surface and ground water. The increasing use of nitrogenous and phosphatic fertilizers has resulted in serious impact on environment by increased nitrate contents in surface and ground water, which has been a cause of major concern in both developed and developing countries. Tames and Lee rivers of USA are living example of nitrate pollution where nitrate content was below 4 mg/1 in 1940 and was reciirded more than 17 mg/1 in 1986. Similarly, high nitrate problem is noticed in many other parts of USA, UK and India (Tripathi 1986). Nitrate level in some parts of Haryana and Punjab is at alarming level due to excessive use of fertilizers. A Summary of some of the investigations made by previous authors on nitrate, phosphate and fluoride contents of ground water in some of the states is given in Table 1. Plants take a part of the fertilizer directly or by hydrolysis of urea to amine, a part by denitrification and leaching ultimately loses rest.

Excessive nitrate concentration in drinking water poses an immediate and serious health threat to infants less than six months. The nitrate ions react with blood hemoglobin, reduces blood's oxygen carrying capacity, this produces a disease called blue baby or methamoglobinemia. A further potential health hazard may be the formation of carcinogenic nitrosoamines in human digestive system by conversion of nitrate and subsequent reactions with amino acid.

Phosphate is strongly adsorbed onto the soil complex and immobile in the soil water environment. However, some factors that result in mobility of phosphate in ground water may be sandy nature of strata, presence of organic matter, occurrence of high water table and excessive addition of phosphatic fertilizer (Handa 1983). The fertilizer use efficiency of phosphatic fertilizer is very low; therefore, chances of loss of phosphate through runoff are always there. Another important implication of phosphatic fertilizer use is the increase in the heavy metal content of soil, and which may go to surface water and ground water due to runoff, as significant quantity of heavy metals like mercury, cadmium, vanadium, uranium nickel etc are present in the rock phosphate.

Summary of Environmental Impact of Fertilizer Production and Use

Major environmental apprehensions from fertilizer manufacture are:

- Deterioration of environment due to off plant activity which includes oil processing for naphtha and natural gas, mining of coal, gypsum, rock phosphate, benification, resulting in solid waste, wastewater, particulates, heavy metals etc.
- Deterioration in air quality due to emission of fluorine, particulates, NOx, SOx, acid fumes etc.

- Deterioration in the surface and ground water quality due to presence of high nitrate, fluoride, suspended and dissolved solid, ammonia, oil & grease, heavy metals, cyanide etc.
- Environmental deterioration due to noise pollution at various stages like ammonia manufacture, urea manufacture, rock phosphate mining, grinding, granulator, boiler blow downs, boiler, turbine, compressors etc.
- Adverse impact on biological environment due to various toxic pollutants discharge in water and air during production and application of fertilizer.
- Adverse impact on the land environment due to various solid waste like over burden from mining and benification stages wastes, phosphogypsum, fly ash, effluent treatment plant sludge, chromium bearing sludge.
- Fertilizer use efficiency in India is low. Increasing use of fertilizers and over fertilization has resulted in deterioration of surface and ground water quality through loss of nutrient, immobilization or even fixation. Undesirable over supply in mobile form in the soil resulting in the presence of nitrates, phosphates, heavy metals and fluorine in the ground water. Concentration of these pollutants is well above the prescribed limits in ground water at many parts of the country.
- Socio-cultural disruption due to influx of labour force, migration from outside, movement of heavy machinery, additional traffic etc.

The basic resources which are likely to be affected due to location / expansion / modernization of the fertilizer manufacturing activities are:

- **Physical component:** Meteorology, air quality, surface water, ground water and hydrology, topography, geology.
- **Ecological Environment:** Fresh water ecology, terrestrial flora and fauna, natural vegetation, species diversity, bacterial population, eutrophication, plant productivity.
- **Human use value and socio-economic & cultural aspects:** Land use, transportation, water & power supply, medical & education facilities, industries and other occupation, fisheries, animal husbandry, gross economic yield etc.

Environmental impact identification and impact assessment network for nitrogenous and phosphatic fertilizer manufacture activities is shown in Fig. 5.

Role of Environmental Impact Assessment (EIA) on Sustainable Fertilizer and Agricultural Development

Green revolution to meet the fast growing demand of food grains need high yielding varieties of seeds, which rely heavily on irrigation, fertilizers, and pesticides. This is serious environmental problem and calls for sustainable agricultural development. Constitutional pre conditions, which must be satisfied while working for goal of sustainable development, are equity and social justice, economic efficiency, ecological harmony and endogenous choice (Khanna *et al.* 1989).

EIA is an activity designed to identify and predict the impact on the bio-geophysical environment and on man's health and well being of legislative proposal, policies, programme, projects and operation procedures and to interpret and communicate information about its impact. As per EIA notification 1994 by Ministry of Environment and Forest, EIA has been made mandatory

When we are looking towards 21[st] century and projection of population to about 1.2 billion by 2011. The fertilizer industry would need at least two times growth with about 20 million tones of nitrogenous, phosphatic and mixed fertilizers including the compensation for current gaps in meeting the food grain demand (Singh 1996). Increasing demand of both nitrogenous and phosphatic fertilizers will require huge amount of natural gas, naphtha, coal, fuel oil, rock phosphate, sulfur/ sulphuric acid etc. Therefore, fertilizer industry has to take effective environmental management plan in the following areas.

- Reducing emission of ammonia, at various levels of operation.
- Reducing the emission of fluorine at various stages of operation by scrubbing the fluorine laden gases and their subsequent utilization by use of computer base dual scrubbing system consisting of venturi scrubber combined with packed column.
- Reduction in the wastewater generation by more and more recycling and utilisation of zero discharge technologies.
- Reduction in the emission of SO_2 and acid mist through better controls of operating parameters during conversion and absorption stages by on-line control, as in many plants emissions are still at higher value.
- Use of molecular sieve absorber to recover trace quantities of toxic pollutants.
- Improvement in the acid mist eliminator.
- On line monitoring of pollutants.
- Proper utilisation of carbon, phosphogypsum, coal fly ash. Some of the applications of phosphogypsum may be in gypsum plaster, gypsum ceiling tiles, gypsum marble products, gypsum board and cement.

Although increasing losses of nutrients is an unavoidable consequence of increased fertilization, however, fertilizer use efficiency can be improved to avoid agricultural drainage through proper agronomic approaches that includes.

- Use of proper size and type of fertilizer
- Avoidance of excessive use of fertilizer through balance fertilization based on soil test
- Split up of the fertilizer dose
- Avoidance of excessive use of irrigation water
- Effective control of weeds
- Ensuring proper plant spacing for optimum fertilizer use
- Proper control of pests and diseases
- Selecting most responsive and best suited crops and their varieties for the locality
- Proper scheduling of planting/ sowing

Introduction of leguminous crops in diverse rotational and inter cropping sequence.

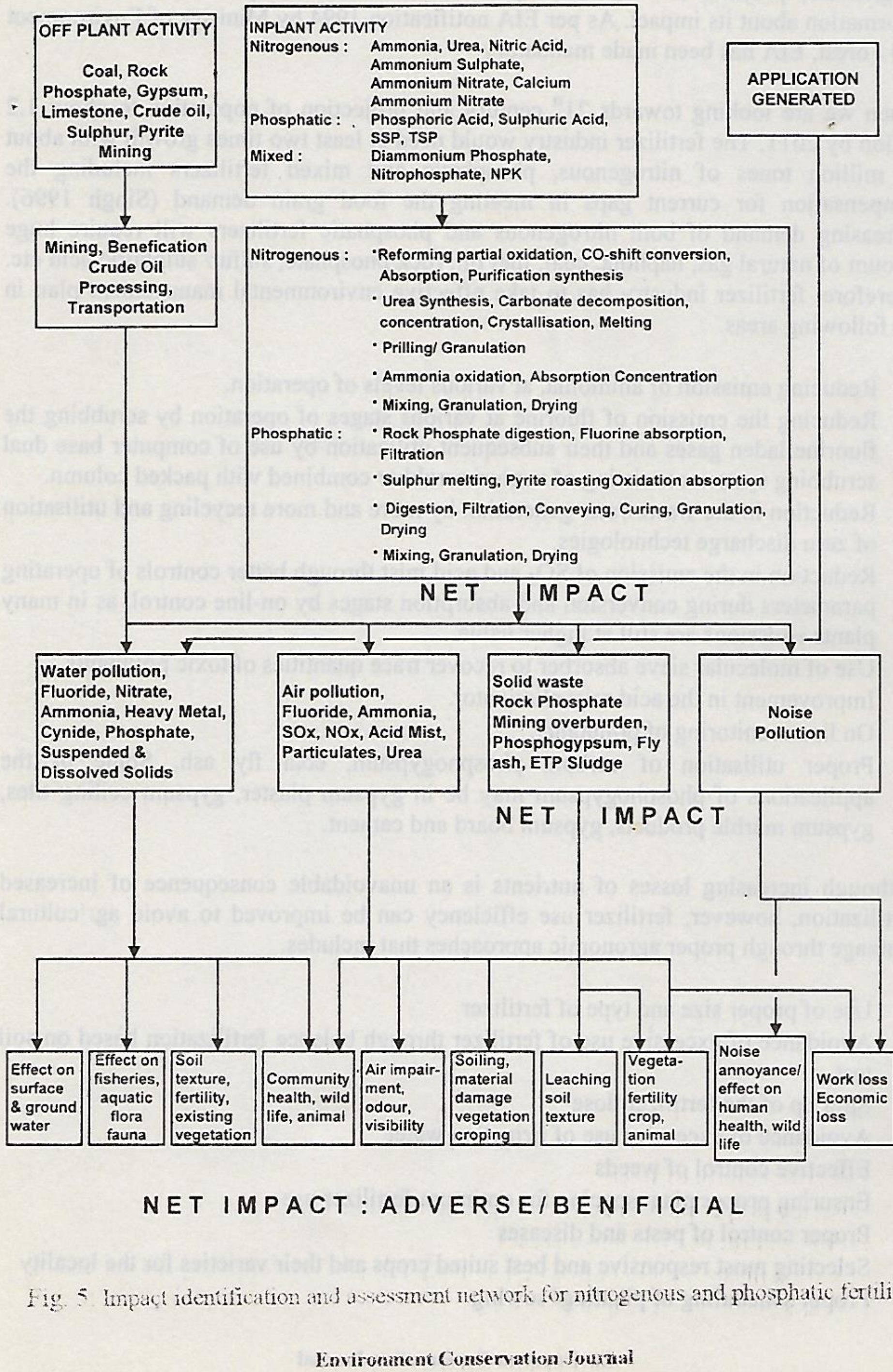

Fig. 5 Impact identification and assessment network for nitrogenous and phosphatic fertilizer

Table 1. Impact of fertilizer production and use on ground water

Reference	Findings
Kakkar 1981	High nitrate concentration in Ground water of Haryana
Handa 1985	Nitrate level in dug well 100 – 300 mg/L Potassium> 100 mg/L, PO_4 1.0 – 3.65 mg/L (Chhata, Mathura and Moradabad, U.P.) Dug well of Agra: Nitrate level -1302 mg/L Assam, West Bengal, Orissa, Kerala – 100 mg/L
Gupta 1991	Out of 1080 samples, average nitrate level was recorded to 271 mg/L. Fluoride was also on higher side.
Gupta *et al.* 1993	Fluride in ground water of 77 villages Minimum 2.28 mg/L Maximum – 22 mg/L
Andamuthu and Subbaram 1994	Out of 129 well water 36.45 % samples exceeded the limit of nitrate concentration. Average nitrate level was found to be 41.7 mg/L at Bhayani, Tamilnadu
Nawlakhe *et al.* 1994	Nitrate 0 – 246 mg/L, Fluoride 0.2 – 5.2 mg/L at Palamu, Bihar
Prasad *et al.* 1994	Nitrate 0.1 to 200 mg/L, Fluoride 0.3 to 1.8 mg/L in North Bihar
Rao *et al.* 1994	Fluoride 0 – 12.5 mg/L in ground water of Unnao (U.P.) and Shivpuri (M.P.)
Singh *et al.* 1994	NO_3 4 – 4400 mg/L In Rajgarh Tehsil, Churu District of Rajasthan)
Joshi *et al.* 1995	Nitrate level 1.2 – 164 mg/L in bore wells , 1.3 to 150 mg/L in dug wells. Rural area of Nagpur

Conclusions

With the increasing population the demand of fertilizers is bound to increase. According to working group on fertilizer for the Eight Plan the gap between demand and production will go up by 3.6 million tones by 2001-2002. More and more fertilizer projects are likely to be implemented in order to bridge the gap. Fertilizer industry has to play an important role in controlling the emission and discharges to safe limit and save the mankind from environmental disaster. Unsound environmental management plan and non-judicious use of fertilizers are liable to affect the vital component of the environment namely water, air, soil and biological. Fertilizer use efficiency has to be increased to avoid the ground and surface water contamination with nitrate by proper agronomic and chemical approaches. Although implementation of new projects, expansion of existing plants are unavoidable, however, various environmental parameters which are likely to have impact on the environment are to be critically examined before setting up a new plant or going for expansion. Effective environmental management plan and post operation monitoring of various parameters are to be incorporated in case of new projects. Fertilizer industry and agronomist has to play an important role for sustainable agricultural development in achieving environmental equity both intergenerational and intersociety by sound environmental management plan and improved soil, crop and irrigation management policies.

References

Aggarwal A. N., 1996. Overview and Fertilizer scenario in India, Indian Chemical Engg. Congress, 1996 held at IICh.E Regional Centre, Ankleshwar, Dec. 18-21.

Andomuthu, R., Subburam, 1994. Nitrate contamination in general water of lower Bhawani Project. *IJEP* **14 (6), 462**.

Awasthi, U. S., 1997. Future process technologies in industries: Fertilizers, *Proceedings of the IICh.E Golden Jubilee Congress,* **Vol. II***,* Dec. 14-18.

Barnes D., Ferster C. F., Hrudex, S.E. 1987*. Surveys in Industrial Wastewater Treatment,* **Vol. 3**, Manufacturing and Chemical Industry. Longman Scientific and Technical, John Wiley and Sons Inc., Newyork.

Central Building Research Institute, 1993. Technology Profile, **BMT/TP, 7/93**

Gomaa, Hassan, S., Leblanc. Jr., 1985. Environmental consideration for the nitrogen fertilizer industry, *Fertilizer News*, **30(6), 23**.

Gupta, M.K., Singh, Vibha, Raghuvanshi, P, Srivastava, S. and Dass, S. 1993. Ground water fluoride levels in a rural area of district Agra. *IJEP*,**14 (5) 370** .

Gupta S.C., 1991. Chemical character of groundwater in Nagaur district of Rajasthan. *Indian Jl. Env. Health*, **33 (3), 345**.

Handa, B. K. 1983. Effect of fertilizer use on general water quality in India. *Proceeedings of Seminar on Ground Water Development – A Perspectives for Year 2000 A.D.*, held at University of Roorkee, Indian Water Resources Society, Roorkee (U.P.), Dec. 19-20, **451 – 462**.

India 1995. *A Reference Annual*, Publication division, Ministry of Information and Broadcasting, Govt of India.

Indian Fertilizer Industry, A Review, 1995. CEW **Vol. 33 (12), 61**.

Joshi, V. A., Dhodapakar, R. S., Desh Pande, L. S. and Nahoti, M. V. 1995. Nitrate in rural area of Nagpur. *IJJEP*, **15(6), 409**

Kakkar, Y.P. 1981. Nitrate Pollution of ground water in southern and southwest Haryana.In: W. Van Duijvanbooden, P. Glassbergen and H. Van Lelyveld (eds), *Proc. Internat. Symp. on Quality of ground water*. Elsevier Scientific Publ. Co. Amsterdam, **125-129**.

Katiyar, S. C., Mall, I.D., Rai, A. K. and Upadhyay, S.N. 1988. Environmental impact of fertiliser production and utilisation in India. In: *Proceedings of the Seminar on Fertilizer Industry Process Problems and Perspectives,* held at Department of Chemical Engineering, B.H.U, Varanasi, Jan 21-23, 1988 **Vol II, pp 105**.

Khanna, P., Sarswat, N. and Kulkarni, V.S. 1989. National environmental perspective for the Year 2000 AD and beyond, *Journal IAEM*, **16, 43**.

Landge, K.A. and Ranade, B.M. 1995. Gas cleaning system by venturi scrubber in fertilizer plant, *Chemical Business*. **9, 70.**

Mahajan, S.P. 1985. *Pollution Control in Process Industries*. Tata McGraw Hill Publishing Co., New Delhi.

Narayan, P. 1990. Structural Reforms and the Fertilizer Industry. Seminar on Indian Fertilizer Scenario Options for the Future, Held at BHU, Varanasi, March 22-23, 1990.

Nawlakhe, W.G., Govindwar, S. L., Ratnaparkhi, D.Y., Mehta, C.G.and Gokhe, B.H. 1994. Water quality in Palamau district in Bihar. *J IWWA*. **26 (1), 9**.

Prasad, L., Chatterjee, D.B. and Sharma, C. B. 1994. Water quality assessment and treatment study in existing dispersed groundwater resources in Bihar. J IWWA, **26 (2), 109.**

Rama Rao, M., Shuji, C. J., Leelo Iyenger and Venkobachar, C. 1994. Fluoride in ground waters of Unnao (U.P.) and Shivpuri (M.P.) Districts. *J IWWA*. **26(3), 180**

Singh L. B. 1996. The Chemical Industry - Vision 2020 - A Technological Assessment Chemical Weekly Business Outlook Conference 96, **87**.

Singh, R. V., Vinod Kumar, Meenakshi, Mathur, S. L. and Gopal, R. 1994. Groundwater quality of Rajgarh tehsil of Churu district in Rajasthan. *J.IWWA*. **26(1), 13**.

Swamy N. K. 1990. Control of fluorosis - An interdisciplinary approach. ***IJEP*. 10, 181**.

Tripathi, S. K. 1986. Nitrate pollution through crops by injudicious fertilizer use. *Seminar on Environmental Considerations in Planning of W.B. Projects* **24-25**, April 1986.

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Impact of Abiotic Factors on the Phytoplanktonic Population of A Pond

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Key Words: ***Pond, Phytoplankton, Seasonal***

Abstract

An investigation was conducted on the water quality and phytoplanktonic diversity of a pond. During the present study total 20 genera were recorded. The study revealed that highest phytoplanktonic population (1416 units/ ml) was recorded during winter season, whereas the lowest phytoplanktonic population (90 units/ ml) was recorded during monsoon season. Chlorophyceae was found to be a dominating group. The annual percentage of Chlorophyceae, Bacillariophyceae and Cyanophyceae was recorded 58.3 %, 27.6 % and 14.1 % respectively. Among the Chlorophyceae, *Cosmarium, Ankistrodesmus, Closterium, Chaetophora* and *Cladophora* were dominating genera. *Desmidium, Nitzschia* and *Cymbella* dominated the Bacillariophyceae and *Anabena, Oscilatoria* and *Nostoc* dominated the Cynophyceae.

Introduction

The present investigation was conducted on a pond situated at Hardwar between longitude 29° 58' north and latitude 78° 13' west. This pond receives water as well as waste from the surrounding area; the pond basically is a rain fed and has water round the year. In Himalayan region, several scientists have conducted various studies on the limnological aspects of ponds and streams (Badola and Singh 1981, Singh *et al.* 1982, Dobriyal 1985, Nautiyal 1985, Gautam 1990 and Khanna 1993). The present study was carried out to investigate the impact of abiotic factors on the phytoplanktonic population of a rain fed pond.

Materials and Methods

The water and phytoplankton samples were collected for a period of one year from October 1998 to September 1999. Physico-chemical parameters were analyzed by using the methods of APHA- AWWA-WPCF 1976 and Trivedy and Goel 1984.

Results and Discussion

The results of physico-chemical parameters are shown in Table 1 & 2, and Fig. 1. The water temperature showed a rise in summer season whereas fall in winter season; this is mainly because of the atmospheric temperature. The total solids, total dissolved solids and turbidity were on higher side during the summer season, this was mainly due to runoff coming from the surrounding along with the sand and silt.

The pH was observed slightly alkaline round the year. The maximum pH was recorded during summer and minimum during monsoon. Free CO_2 was recorded maximum in monsoon and minimum in winter season. This may be because of high turbidity during monsoon, which affects the photosynthetic activity of phytoplankton adversely. Maximum values of total alkalinity and total hardness were recorded during winter season and lowest during monsoon season. Maximum dissolved oxygen was recorded during winter season and minimum during monsoon season. The higher DO during winter season may be due to the lower water temperature and higher photosynthetic rate attributed to higher phytoplanktonic population. Higher BOD was recorded during monsoon season mainly because of the ingress of organic material from surrounding along with the rainwater.

Table 1. Seasonal variation in physical parameters between Oct. 1998 and Sept. 1999

Sl. No.	Parameters	Values			
		Winter	Summer	Monsoon	Average
01	Temperature (°C)	10.6 ± 0.73	20.5 ± 0.46	15.8 ± 0.812	15.63 ± 0.67
02	Total Solids (mg/L)	376 ± 9.73	457.5 ± 6.317	788.6 ± 12.75	534.03 ± 9.60
03	Total Dissolved Solids (mg/L)	254 ± 7.04	308.66 ± 5.43	490.6 ± 4.64	351.09 ± 5.70
04	Turbidity (JTU)	30.5 ± 0.33	24.5 ± 0.53	37.18 ± 0.226	30.73 ± 0.36
05	Transperancy	50.2 ± 0.08	49.1 ± 0.1	37.75 ± 0.04	45.65 ± 0.07

Table 2. Seasonal variation in chemical parameters between Oct. 1998 and Sept. 1999

Sl. No.	Parameters	Values			
		Winter	Summer	Monsoon	Average
01	pH	7.11 ± 0.09	7.58 ± 0.07	7.30 ± 0.14	7.33 ± 0.10
02	Free CO_2 (mg/L)	8.01 ± 0.58	11.3 ± 0.21	12.88 ± 0.47	10.73 ± 0.42
03	Total Alkalinity (mg/L)	345.7 ± 4.75	238 ± 2.77	233.2 ± 2.03	272.30 ± 3.18
04	Total Hardness (mg/L)	234.8 ± 2.11	224.9 ± 2.97	170.16 ± 0.62	209.95 ± 1.90
05	Dissolved Oxygen (mg/L)	10.85 ± 0.12	7.69 ± 0.47	6.42 ± 0.06	8.32 ± 0.22
06	Biological Oxygen Demand (mg/L)	3.63 ± 0.11	4.16 ± 0.08	5.49 ± 0.177	4.43 ± 0.12

The results of phytoplanktonic investigation are shown in Table 3- 6 and Fig. 2. The highest total count of phytoplankton i.e. 1416 units/ ml was recorded during winter season and lowest i.e. 960 units/ ml during monsoon season. Three major groups i.e. Chlorophyceae, Bacillariophyceae and Cyanophyceae were recorded during the present investigation. Individual groups also showed the same pattern except Bacillariophyceae, which shows lower values during monsoon season. Different species recorded during the present investigation along with the results are shown in Table 4–6. Total 13 genera were recorded under the Chlorophyceae, 4 genera under the Bacillariophyceae and 3 genera under Cyanophyceae.

Table 3. Seasonal variation in phytoplankton between Oct. 1998 and Sept. 1999

Sl. No.	**Parameters**	**Values**			
		Winter	Summer	Monsoon	Average
01	Total Phytoplankton (units/ ml)	1416 ± 10.8	1188 ± 9.66	960 ± 7.65	1188 ± 9.36
02	Chlorophyceae	915 ± 4.8	721 ± 2.24	476 ± 3.24	704 ± 3.43
03	Bacillariophyceae	321 ± 3.2	300 ± 3.25	336 ± 4.26	319 ± 3.57
04	Cyanophyceae	180 ± 2.8	167 ± 1.24	148 ± 3.26	165 ± 2.43

Percentage variation

01	Chlorophyceae	64.6 %	60.7 %	49.5 %	58.27 %
02	Bacillariophyceae	22.7 %	25.2 %	35.0 %	27.63 %
03	Cyanophyceae	12.7 %	14.1 %	15.4 %	14.07 %

Table 4. Seasonal variation in Chlorophyceae between Oct. 1998 and Sept. 1999

Sl. No.	**Parameters**	**Values**			
		Winter	Summer	Monsoon	Average
01	*Ankistrodesmus*	133 ± 1.25	82 ± 2.10	0.0 ± 0.0	71.67 ± 1.12
02	*Chatophora*	127 ± 0.76	70 ± 2.25	0.0 ± 0.0	64.67 ± 1.00
03	*Caldophora*	113 ± 0.50	62 ± 0.76	0.0 ± 0.0	58.33 ± 0.42
04	*Clostrium*	115 ± 1.50	89 v 4.20	0.0 ± 0.0	68.00 ± 1.90
05	*Coaelastrum*	111 ± 2.10	88 ± 3.27	0.0 ± 0.0	66.33 ± 1.79
06	*Euglena*	0.0 ± 0.0	50 ± 0.78	81.0 ± 0.56	43.67 ± 0.45
07	*Cosmarium*	120 ± 4.25	91 ± 5.12	82.0 ± 2.25	97.67 ± 3.87
08	*Microcystis*	0.0 ± 0.0	0.0 ± 0.0	80.0 ± 8.45	26.67 ± 2.87
09	*Oocystis*	0.0 ± 0.0	43 ± 8.16	64.0 ± 5.75	35.67 ± 4.64
10	*Sphaerocytis*	97 ± 8.75	54 ± 2.14	0.0 ± 0.0	50.33 ± 3.63
11	*Volvox*	0.0 ± 0.0	0.0 ± 0.0	62.0 ± 0.84	20.67 ± 0.28
12	*Stigeoclonium*	0.0 ± 0.0	0.0 ± 0.0	50.0 ± 0.95	16.67 ± 0.32
13	*Ulothrix*	109 ± 10.25	95 ± 7.05	57.0 ± 1.24	87.00 ± 6.18

Table 5. Seasonal variation in Bacillariophyceae between Oct. 1998 and Sept. 1999

Sl. No.	**Parameters**	**Values**			
		Winter	Summer	Monsoon	Average
01	*Cymbella*	69 ± 2.36	0.0 ± 0.0	95 ± 3.3	54.67 ± 1.87
02	*Desmidium*	97 ± 4.21	107 ± 2.27	115 ±2.1	106.33 ± 2.87
03	*Navicula*	73 ± 0.76	85 ± 0.45	0.0 ± 0.0	52.67 ± 0.40
04	*Nitzschia*	82 ± 5.24	108 ± 3.24	116 ± 0.56	102.00 ± 3.01

Table 6. Seasonal variation in Cyanophyceae between Oct. 1998 and Sept. 1999

Sl. No.	Parameters	Values			
		Winter	Summer	Monsoon	Average
01	*Oscillatoria*	74 ± 4.50	69 ± 2.24	76 ± 1.35	73.00 ± 2.70
02	*Anabaena*	59 ± 3.40	54 ± 1.15	72 ± 3.70	61.67 ± 2.75
03	*Nostoc*	47 ± 2.40	44 ± 0.76	0.0 ± 0.0	30.33 ± 1.05

To analyze the impact of abiotic factors on the phytoplanktonic population correlation coefficient was calculated between several parameters. The data are shown in Table 7. It is evident from the analysis that phytoplankton have negative relationship with temperature (r = - 0.51), CO_2 (r = - 0.65) and BOD (r = - 0.96) whereas it has positive relationship with dissolved oxygen (r = + 0.97). Therefore, higher temperature, free CO_2 and BOD does not favor the growth of phytoplankton. Higher DO is due to the higher photosynthetic rate of the phytoplankton.

Correlation coefficient was also calculated between several physico-chemical characteristics, the data are shown in Table 7. Dissolved oxygen showed a significant negative relationship with temperature (r = - 0.76), free CO_2 (r = - 0.86) and BOD (r = - 0.88). Free CO_2 showed a positive correlation with temperature (r = + 0.59) and BOD (r = - 0.78).

Table 7. Correlation between abiotic factors and phytoplankton

Sl. No.	Parameters	Coefficient of correlation
01	Temperature and Free CO_2	+ 0.59
02	Temperature and Dissolved Oxygen	- 0.76
03	Free CO_2 and Dissolved oxygen	- 0.86
04	Free CO_2 and BOD	.+ 0.76
05	Dissolved oxygen and BOD	- 0.88
06	Temperature and Phytoplankton	- 0.65
07	Free CO_2 and Phytoplankton	- 0.65
08	Dissolved oxygen and Phytoplankton	+ 0.97
09	BOD and Phytoplankton	+ 0.96

Therefore, higher turbidity and BOD adversely affected the growth of phytoplankton during monsoon season which in turn resulting in the lower DO and higher free CO_2 values. Similar findings were also reported by Badola and Singh 1981 and Nautiyal 1985 on the river Alaknanda, Dobriyal 1985 on the river Mandakini, Singh *et al.* 1982 and Nautiyal 1985 on the river Nayar, Khanna 1993 on the river Ganga., Das and Akhtar 1940 on the Dal lake, Adholia 1991 on the Mansarovar reservoir. In the present investigation temperature also played an important role in the growth of phytoplankton, which support the findings of Dobriyal 1985 and Khanna 1997. Nautiyal 1985 did not report any relation between temperature and phytoplankton.

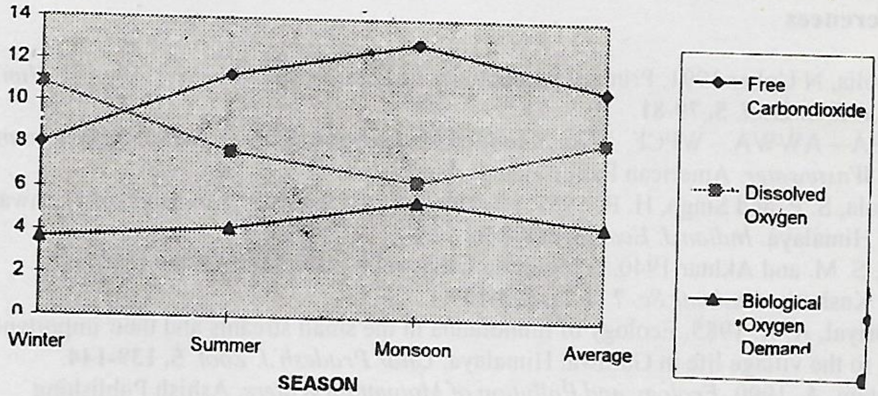

Fig. 1 : Seasonal variation in free CO_2, DO and BOD

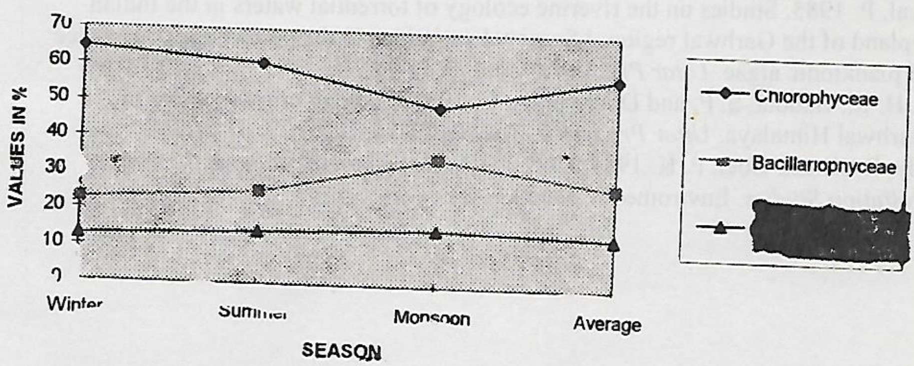

Fig. 2: Seasonal variation in the percentage of Phytoplankton

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References

Adholia, N Upkar 1991. Primary productivity of Mansoravar Reservoir, Bhopal. *Him. J. Env. Zool.* **5, 79-81**.

APHA – AWWA – WPCF 1976. *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association

Badola, S. P. and Singh, H. R. 1981. Hydrobiology of the river Alaknanda of Garhwal Himalaya. *Indian J. Ecol.* **8, 269-276**.

Das, S. M. and Akhtar 1940. A report on fresh water plankton from the Dfal lake, Kashmir. *Kashmir Sc.* **7 (1-2), 133-137**.

Dobriyal, A. K. 1985. Ecology of limnofauna in the small streams and their importance to the village life in Garhwal Himalaya. *Uttar Pradesh J. Zool.* **5, 139-144**.

Gautam, A. 1990. *Ecology and Pollution of Maountain Waters*. Ashish Publishing House, New Delhi.

Khanna, D. R. 1993. *Ecology and Pollution of Ganga River*. Ashish Publishing House, New Delhi.

Khanna, D. R., Malik, D. S. and Badola, S. P. 1997. Population of Green Algae in relation to physico-chemical factors of river Ganga at Lal-Ji-Wala, Hardwar. *Uttar Pradesh J. Zool.* **17(3), 237-240**.

Nautiyal, P. 1985. Studies on the riverine ecology of torrential waters in the Indian Upland of the Garhwal region. I Seasonal variations in the percentage occurrence of planktonic algae. *Uttar Pradesh J. Zool.* **5, 14-19**.

Singh, H. R., Badola, S. P. and Dobriyal, A. K. 1982. Ecology of river Nayar of Garhwal Himalaya. *Uttar Pradesh J. Zool.* **2, 72-76**.

Trivedy, R. K. and Goel, P. K. 1984. *Chemical and Biological Methods for Water Pollution Studies*. Enviromedia, Karad.

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Quality Monitoring of The Effluent from Fertilizer Industry

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Key Words: Fertilizer, Effluent, Quality, Impact

Abstract

Importance of natural resources i.e. water and its requirement in a fertilizer industry have been described in the present paper. The effluent samples of a fertilizer plant situated in U.P. have been collected and analyzed for several physico-chemical characteristics to assess the pollution load of the effluent.

Introduction

Today, India is one of fastest growing industrialized country of the world. India has a good industrial infrastructure in core industries like chemicals, metals, fertilizers, petroleum, food products, etc. Each industry has its own water requirements. The water once it is used for industrial purpose cannot be used for any purpose without treatment. The quality of such water is characterized by their physical, chemical and biological properties.

In fertilizer production, water is an auxiliary input. Depending on the feedstock such as fuel oil, naphtha, coal and natural gas and process technology, consumption of water for a tone of urea varied from 9.0 m^3 to 40.0 m^3 with the plant operating at 90 % capacity. Most of the pollutants from a fertilizer plant emerge as a part of liquid effluent. This effluent generally has high pH, high ammonia, high acidity or alkalinity, organic matter, high nitrogen, potassium etc. On the direct disposal into water bodies, such untreated effluents, causes harmful diseases and have disastrous effects on the living organisms. (Sharma and Kaur 1994). Due to high level of toxicity, it is important to monitor the quality of such effluents on regular basis and maintain the standards prescribed by the Government agencies to keep environment healthy.

Keeping this in view present study was undertaken and the results are presented in this paper.

Materials and Methods

A fertilizer complex, Tata Chemicals Limited (TCL), selected for the study is situated at Babrala, in the district Badaun of Uttar Pradesh. This fertilizer complex is situated between the drainage basins of two small rivulets, Burdmar and Mahawa. Burdmar with its meandering course flows from NW to SE. It is very close to the complex. In this fertilizer complex the main plants are Urea and Ammonia.

During the manufacturing process of urea, the major potential liquid effluents emanating from various units are ammonia plant, urea plant, demineralization plant, cooling towers, and sanitary waste. The sampling from the following locations has been done for detailed investigation.

A. Effluent treated in the Individual Battery limit

- Ammonia plant process condensate
- Urea plant process condensate
- Demineralization plant regeneration effluent
- Cooling tower blow downs from ammonia and urea cooling towers

B. Effluent treated in effluent treatment plant (outside the main plant)

- Floor washings/ process drains from ammonia plant
- Floor washings/ process drains from urea plant
- Oil leakages/ spillages from ammonia and urea plants

C. Sanitary waste treated in sewage treatment plant

D. Guard pond where all the treated effluents collected for equalization

The standard parameters like - pH, ammonia, free ammonia, urea, total solids, total dissolved solids, total suspended solids, total Kjeldahl nitrogen, nitrate, phosphate, sulphate, dissolved oxygen, BOD, COD and oil & grease were selected for the study.

Standard methods described by Trivedy and Goel 1986 and Manivaskam 1996, were used for the analysis of above stated parameters.

Results and Discussion

Effluent flow and treatment scheme at the fertilizer complex, under investigation, is shown in Fig. 1. The values of various parameters are shown in Table 1 and Table 2. Detailed discussion of the findings is as under.

Ammonia plant process condensate discharged from ammonia plant is sent to steam stripper, which under high temperature and pressure removes all the impurities. The observed values for ammonia in untreated and treated effluent were 982 mg/L and 5 mg/L respectively. As per the findings of Melin *et al.* 1975, the concentration of ammonia varied from 100 to 1300 mg/L in untreated effluent and from 5 to 100 mg/L in treated effluent.

Table 1. The characteristics of treated and untreated effluent

Sl. No.	Parameters	Units	Values	
			Untreated effluent	Treated effluent
01	pH		9.36	9.22
02	Ammonia	mg/L	379	19
03	Free Ammonia	mg/L	209	8.5
04	Urea	mg/L	376	152

Table 2. Characteristics of effluent from guard pond

Sl. No.	Parameters	Units	Values
01	pH		7.8
02	Ammonia	mg/L	32.6
03	Free Ammonia	mg/L	1.14
04	Urea	mg/L	61.0
05	Total Solids	mg/L	2082
06	Total Dissolved Solids	mg/L	2010
07	Total Suspended Solids	mg/L	72
08	Total Kjeldahl Nitrogen	mg/L	51.4
09	Nitrate	mg/L	3.526
10	Phosphate	mg/L	690
11	Sulphate	mg/L	690
12	Dissolved Oxygen	mg/L	6.3
13	Biological Oxygen Demand	mg/L	18.4
14	Chemical Oxygen Demand	mg/L	80
15	Oil and Grease	mg/L	5.34

Urea plant process condensate discharged from urea plant is sent to hydrolyser-cum-stripper which under high temperature and pressure converts urea in to ammonia and carbon di oxide and removes all the impurities. Melin *et al*. 1975, on the investigation of various urea manufacturing plants, found the concentration of ammonia and urea 3000 mg/L and 4000 mg/L respectively for untreated effluent and 50 and 100 mg/L respectively for treated effluent. In the present investigation, values for ammonia and urea were recorded 6580 mg/L & 2880 mg/L for untreated and 2 mg/L & 2 mg/L respectively for treated effluent.

The treated effluent from both ammonia and urea plants containing ammonia and urea less than 5 mg/L is recycled as boiler feed water.

The demineralization plant consists of three numbers each of strong anion – cation exchanger I and II in series, weak base anion exchanger and strong base anion exchanger in series and mixed bed units. The weak acidic and alkaline effluents are generated from these units, which mixed proportionately and neutralized in neutralization pit. The values for pH and total solids were recorded 8.5 and 2060 mg/L respectively. This effluent is pumped to guard pond after proper neutralization.

Cooling water treatment is non-chromate based. Biocides and dispersants are added in cooling water blow down for the treatment of cooling water. These are non-toxic and biodegradable; therefore, the effluent generated from this part is non-toxic. The values for pH, total dissolved solids and dissolved oxygen were recorded 7.5, 2240 mg/L and 6.5 mg/L respectively in treated blow downs.

All the floor washings/ process drains are collected in floor washing pit in ammonia and urea plants. From where, these are sent to untreated effluent tank in effluent treatment plant. The run off water from compressor house, pump house, interstage separators of compressors are normally polluted with oily water along with oil spillage from refrigeration systems. These effluents are collected separately in a oil water pit and pumped to oil separator in effluent treatment plant. The clear effluent having less than 5 mg/L of oil and grease is also sent to untreated effluent tank. The combined effluent collected in untreated effluent tank had pH 9.4, ammonia 379 mg/L, free ammonia 209 mg/L and urea 376 mg/L. This effluent is then sent to steam stripper in effluent treatment plant. The treated effluent, having pH 9.2, ammonia 19 mg/L, free ammonia 8.5 mg/L and urea 152 mg/L, is pumped to guard pond via treated effluent tank.

In the investigated fertilizer complex, sanitary waste comes from the township as well as from the plant premises. Sanitary waste from plant is collected in soak pits/ septic tanks at various locations within the plant area whereas that from township goes to sewage treatment plant. In sewage treatment plant, main unit is oxidation ditch with aerators (to provide air for oxidation). The treated sanitary waste from this unit, after attaining the desirable BOD and total suspended solids, is used as irrigation water for horticulture. At the time of investigation BOD and total suspended solids were recorded

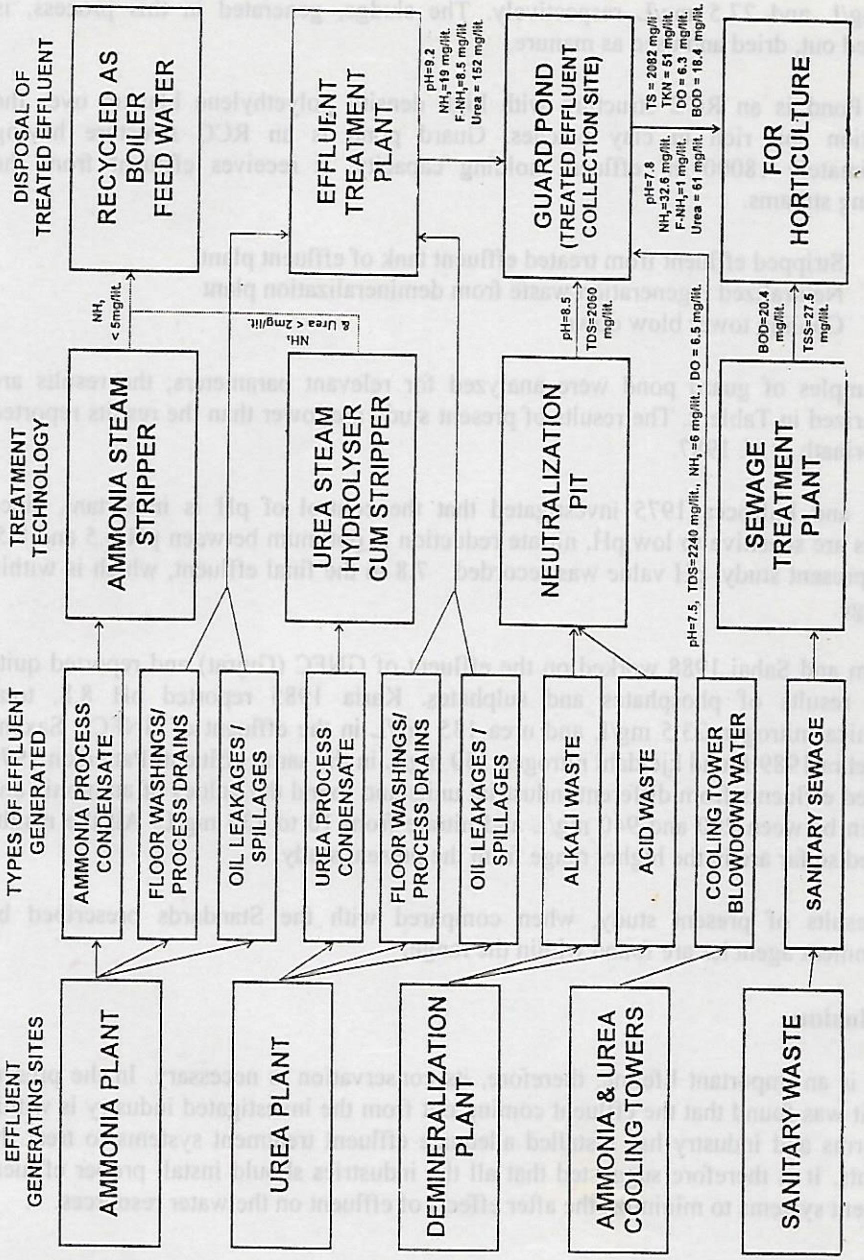

Fig. Effluent flow and treatment scheme

20.4 mg/L and 27.5 mg/L respectively. The sludge, generated in this process, is separated out, dried and used as manure.

Guard Pond is an RCC structure with high density polyethylene blanket over the foundation soil rich in clay patches. Guard pond is an RCC structure having approximately 18000 m^3 effluent holding capacity. It receives effluent from the following streams.

1. Stripped effluent from treated effluent tank of effluent plant
2. Neutralized regeneration waste from demineralization plant
3. Cooling tower blow down

The samples of guard pond were analyzed for relevant parameters; the results are summarized in Table 2. The results of present study are lower than the results reported by Badrinath *et al.* 1987.

Hutton and LaRocca 1975 investigated that the control of pH is important, since nitrifers are sensitive to low pH, nitrate reduction is optimum between pH 6.5 and 8.5. In the present study, pH value was recorded 7.8 in the final effluent, which is within the range.

Neekam and Sahai 1988 worked on the effluent of GNFC (Gujrat) and reported quite higher results of phosphates and sulphates. Karia 1985 reported pH 8.8, total ammonical nitrogen 23.5 mg/L and urea 135 mg/L in the effluent of GNFC. Saxena and Mehra 1989 found kjeldahl nitrogen 150 mg/L in the same effluent. Patterson 1974 analysed effluents from different industrial units and found the values of ammonia and nitrogen between 200 and 940 mg/L and nitrate from 10 to 135 mg/L. All the results reported so far are in the higher range from the present study.

The results of present study, when compared with the Standards prescribed by Government agencies are found within the range.

Conclusion

Water is an important lifeline; therefore, its conservation is necessary. In the present study it was found that the effluent coming out from the investigated industry is within the norms and industry has installed adequate effluent treatment systems to treat the effluents. It is therefore suggested that all the industries should install proper effluent treatment systems to minimize the after effects of effluent on the water resources.

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References

Badrinath, S. K., Kaul, S. N. and Gadkari, S. K. 1987. Fertilizer industries – An environmental appraisal. *IJEP.*, **7(3), 201-208**.

Hutton, W. C. and LaRocca, S. A. 1975. Biological treatment of concentrated ammonia wastewaters. *J. Water Poll. Control Fed.,* **5, 989-997**.

Karia, V. K. 1985. Utilization of urea hydrolyzer effluent as cooling tower, makeup water. *IJEP,* **5(4), 262-267**.

Manivaskam, N. 1996. *Physico-chemical Examination of Water Sewage and Industrial Effluents*. Pragati prakashan, Meerut.

Melin, G. A., Niedzwiecki, J. L. and Goldtein, A. M. 1975. Computer improves sour water stripping. *Oil Gas J.,* **73, 96-98**.

MINAS. 1985. *Straight Nitrogenous Fertilizer Industry – Minimal National Standards*. Central Pollution Control Board, New Delhi.

Neekam, J. I. And Sahai, N. 1988. Physico-chemical properties of certain industrial effluents of Central Gujrat, India. *Indian Jr. Ind. Poll. Cont.,* **7(1), 17-24**.

Patterson, W. J. 1985. *Industrial Wastewater Treatment Technology*. Butterworth Publishers.

Saxena, S. K. and Mehra, K. 1989. Nitrogenous fertilizer industries in India : Need for an effective pollution control strategy. *IJEP,* **9(3), 175-177**.

Sharma, B. K. and Mehra, K. 1994. *Environmental Chemistry*. Goel Publishing House, Meerut.

Trivedy, R. K. and Goel, P. K. 1986. *Chemical and Biological Methods for Water Pollution Studies*. Environmental Publications, Aligarh.