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POLLUTION FROM FERTILIZER PLANTS IN BANGLADESH[1/]

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I. INTRODUCTION

This paper deals with problems associated with pollution from fertilizer plants in Bangladesh. A comprehensive analysis of the fertilizer industry vis-a-vis existing manufacturing facilities and future development prospects is, however, necessary to define the extent of efforts needed for minimizing pollution from these plants.

Bangladesh is situated in the tropical zone of South-East Asia. Bounded by the Bay of Bengal on the South, the Indian Republic on the West, the North and the East and Burma on the extreme South -East, Bangladesh lies between the latitudes of 20° and 27°N and longitudes of 88° and 93°E. A delta in geo-physical form the country has an area of 55,126 square miles or 140,800 square kilometres. The land is an alluvial plain except for some low hilly ranges and dease tropical forests. It is a land of rivers and tributaries. The average temperature ranges between 98 and 120°F in the summer and between 51° and 70°F in the winter. The annual average rainfall is around 80 inches and occurs mainly during the monsoon. The population of Bangladesh is estimated at 762 million in 1974 based on projections from the last census in 1971 growing annually a t the rate of 3 per cent. The 1974 census puts this provisionally at 71.3 million; final figures have not been made available as yet. Eighty per cent of the population live on the land and make their living from agriculture. Some of the more intensively farmed areas support a rural population of 1200 to 1300 persons per square mile. The percentage of literacy is about 21.5 and the people are intelligent and quick to learn.

II. Industtal Strategy.

Industrialization in Bangladesh had been a trying proposition in particular in the public sector where the control was effected from the remote capital, in the western wing of the former Pakistan, about 1500 miles away. As a result, vital industrialization such as the development of fertilizer industry, the importance in the national economy of which can hardly be exaggerated, suffered rather adversely negating even the semblance of benefit which these were supposed to accrue to the nation and to the people.

There can be no two opinions that industrial development in Bangladesh depend on the adoption and implementation of a pragmatic industrial policy capable of mobilising and properly utilising the resources, notably natural gas having a recoverable reserve of 9.36 million million cubic feet, available within the country. In our efforts towards development, self-reliance has been accepted as the key-note and basic instrument. While the primary facet of industrialization should aim at maximising export promotion through accelerating the export of jute goods and other labour-intensive leather products, the other equally important facet of industrialization should seek to accelerate the transformation in agriculture in order to achieve a balanced growth.

The contribution of agriculture in the gross national product is about 46 per cent and to the earnings of export is about 55 per cent in Bangladesh. It is, therefore, very much essential to formulate a policy of agriculture-biased industries. Such a policy will help increase not only the agriculture with the adoption of improved methods of cultivation use of fertilizer and introduction of mechanised irrigation. The increase of agricultural products is interwoven with the availability of fertilizer for increased crop yield to alleviate food shortage.

Increasing the yield per acre is probably the most important means of developing agriculture on sound lines in a region like ours where land is limited and pressure of population is heavy.

Improving soil fertility is one of the most important pre-requisites for increas ing yields. Plant nutrients needed to increase the soil fertility of our already depleted soil cannot be met only from the traditional natural fertilizer such as cowdung and compost. Chemical fertilizers must be made available in large quantities to fill the gap.

III. Fertilizer Industry.

Commercial quantities of chemical fertilizers were first used in Bangladesh in 1955/56 when 11,000 tons of ammonium sulphate were sold to farmers mostly for use on tea. Some two years later in 1957/58 use of urea and triple superphosphate was introduced in very small quantities with consumption of 2,000 tons of urea and 1,000 tons triple superphosphate having been recorded for that year. First commercial use of potassium nutrient was in 1960/61 when a consumption of 1,000 tons of muriate of potash was recorded. Whereas ammonium sulphate usage has remained relatively stable up till the present, demand for TSP, Potash and especially urea, has been steadily increasing since their introduction. Consumption figures for all types of fertilizer are given in Table -I.

To meet these increasing requirements of chemical fertilizer, the country through the agency of its Industrial Development Corporation established its first manufacturing unit at Fenchuganj in 1961 with the construction of a 106,000 tons per year urea plant. In 1968 the first plant for the production of TSP was completed at Chittagong having an annual output of 32,000 tons per year and a little later in 1970-71 a larger such plant having an annual output of 120,000 tons was completed alongside it. Also in 1970 the IDC completed its largest and most modern works to-date with the construction at Ghorasal of a 340,000 ton per year urea plant based on the latest centrifugal compressor technology. At the present time Bangladesh has five fertiliser manufacturing units located at Fenchuganj, Chittagong and Ghorasal, but the operating record of these units has been poor. The urea plant at Fenchuganj, which also can produce 12,000 tons per year of ammonium sulphate since 1966 has shown the best results with a reported average annual output of 87% of rated capacity over the years 1962

TABLE: I PAST FERTILIZER CONSUMPTION IN BANGLADESH IN ('.000 TONS)

Year	Ammonium Sulphate	Urea	N	Single super phosphate	Triple super phosphate	P_2O_5	Muriate of Potash	K_2O	Total product.	Total Nutrient.
1955-56	11	-	2.3	-	-	-	-	-	11	2.3
1956-57	25	-	5.7	-	-	-	-	-	25	5.7
1957-58	30	2	7.0	-	1	0.5	-	-	33	7.5
1958-59	30	4	7.9	-	1	0.5	-	-	35	8.5
1959-60	32	8	10.3	-	2	0.9	-	-	42	11.2
1960-61	27	30	19.0	2	6	3.0	1	0.5	66	22.5
1961-62	29	30	20.0	3	4	2.0	1	0.5	67	22.5
1962-63	25	40	24.0	3	3	2.0	2	1.0	73	27.0
1963-64	8	75	36.0	2	23	11.0	4	2.0	112	49.0
1964-65	7	71	34.0	-	19	9.0	4	2.0	101	45.0
1965-66	21	74	38.3	-	21	9.3	4	2.0	120	54.2
1966-67	6	119	56.3	-	34	15.4	8	4.1	167	75.8
1967-68	15	147	70.9	-	45	20.2	10	4.9	217	96.0
1968-69	11	150	76.1	-	49	24.4	13	7.5	223	108.0
1969-70	-	200	92.2	-	60	30.2	15	9.2	275	131.6
1970-71	6.2	212	98.8	-	76	34.9	18	11.2	306	144.9
1971-72	3.1	170	78.8	-	60	27.6	14	8.6	244	115.0
1972-73	6.0	272	126.4	-	88	40.5	18	11.2	378	178.1

until 1971, the commencement of the war of Independence. Since being restarted after the war, however, performance has been poor with monthly outputs varying between 32 and 60 per cent. Early overhaul of the entire plant is being contemplated at a cost of about US $ 8 million.

Attempts to produce TSP on a commercial basis from the two plants established at Chittagong have so far been unsuccessful. The first plant completed early in 1968 has only made trial runs using Jordanian rock and it is reported that this plant cannot be successfully operated on this raw material. The second plant completed early in 1971 just before the outbreak of war has never been started apparently due to lack of supplies of Florida-grade rock phosphate for which it was designed.

The large modern technology ammonia/urea plant at Ghorasal has similarly been a disappointment to-date. Although it satisfactorily passed its performance tests during start-up, mechanical problems were encountered shortly afterward and persisted until the plant was shut down during the war. When the plant was re-started after the war in August 1972, average output of only about 66 per cent could be achieved. The plant can at present achieve only a maximum of 80 per cent of its rated capacity with breakdowns being still frequent, causing average production rates to be much lower.

IV. Projected Fertiliser Use.

It is necessary to identify food production goods to project fertiliser requirements and plan production facilities. The Bangladesh Planning Commission has set 16 Ozs. of rice per capita per day as a 1977-78 goal when self-sufficiency in food grain production, is expected to be achieved.[1] The achievable food production targets based on an available food grain intake of 16 oz per day for 76.2 million people in 1974 growing at 3 per cent every year, to decline to 2.8 per cent in 1977-78 and to 2.6 per cent by 1982-83 are given in Table II[2].

TABLE: II: **FOOD GRAIN PRODUCTION TARGETS(.000 TONS)**

Year	Population (Million)	Production Rice	Production Wheat	Production Total	Imports	Total Grain	Per capita consumption (Ozs/day)
1968-69	66.5	10,074	83	10,157	1,120	10,158	13.4
1969-70	68.3	10,680	94	10,774	1,540	12,314	15.8
1970-71	70.1	9,944	100	10,044	1,280	11,324	14.2
1971-72	72.0	11,542	101	11,643	1,730	11,373	16.3
1972-73	74.0	9,013	82	9,095	2,840	11,935	14.1
1973-74	76.2	10,736	121	10,857	2,000	12,857	14.8
1974-75	78.5	11,882	138	12,020	1,500	13,520	15.1
1975-76	80.9	13,040	170	13,210	1,000	14,210	15.4
1976-77	83.1	14,186	195	14,381	500	14,881	15.7
1977-78	85.4	15,371	214	15,585	-	15,585	16.0
1978-79	87.8	15,795	228	16,023		16,023	16.0
1979-80	90.3	16,237	242	16,479		16,479	16.0
1980-81	92.8	16,678	258	16,936		16,936	16.0
1981-82	95.2	17,103	271	17,374		17,374	16.0
1982-83	97.5	17,508	285	17,793		17,793	16.0
1983-84	100.2	18,001	285	18,286		18,286	16.0

Notes: 1. Production less 10 per cent seed and waste levels for local varieties and 5 per cent for the high yielding varieties.

2. Total yields from 1974 includes boro yields.

3. Wheat yield from 1975 are based on 300,000 acres of wheat with increasing percentage and yields from current 0.6 ton per acre to 1.0 ton per acre by 0.05 ton per acre annual increments.

4. Self sufficiency in grain to be achieved by 1978.

5. Per capita consumption of 16 oz. per day to be achieved by 1978.

Forecasts of future consumption have to take into account what development of irrigation extension services, distribution and marketing can reasonably be expected during the forecast period, and what pricing policies the Government intends to apply in respect of agricultural inputs and produce. A forecast taking recent developments into account and keeping in view the planned improvements is given in Table-III*. These forecasts are based upon experiences in other countries with similar conditions. Another forecast* which takes into account only the requirements of fertilizer, enabling attainment of sufficiency at a food requirement of 16 ozs. per capita per day by 1978, is given in Table IV in nutrient terms. The projected product needs for food grains and major crops are given in Table-V. The availability of fertilizer from local production has to be viewed in the light of these requirements.

V. Fertilizer Production.

The fertilizer production in Bangladesh is now limited to manufacturing urea at the Fenchuganj and Ghorasal ammonia-urea complex and some ammonium sulphate at the Fenchuganj unit. Triple superphosphate production is expected to commence sometime later this year. From experience, a general appraisal of problems associated with the operational conditions, design deficiencies, general equipment absolescence, general unavailability of spare parts and poor inventory control inadequacy of general support facilities and lack of trained manpower and being acquainted with the mechanical conditions at the production units, an estimate has been made* of the performance and operating rates to be anticipated from the existing units. The performance of Fenchuganj would decline from the present 57 per cent to 47 per cent unless a major and expensive overhaul costing well-over $ 8 million is carried out which would restore the operating rate to 80-85 per cent of capacity allowing the plant to operate at 80 per cent with a minimum of strain on equipment and would extend the life of the plant by 5 to 10 years. The Ghorasal plant shall be in a position to improve its performance from the current 60 to 70 per cent to a sustained production at

TAB-LE : III: **PROJECTED FERTILIZER USE IN BANGLADESH (.000 TONS)**

Crop.	1969-70 Fertilizer use Area million acres.	Rate lb/acre.	'000' tons.	1972-73 Area million acres.	Rate lb/acre.	'000' tons.	1977-78 Area million acres.	Rate lb/acres.	'000' tons.
A. Rice									
Aus(i) Broad-cast local.	8.42	10	38	7.08	10	32	5.7	15	39
ii) Broadcast.HYV	-	-	-	-	-	-	2.2	190	100
iii) Transplanted	0.04	100	2	0.16	100	7	0.3	150	20
Aman i) Broadcast	5.15	-	-	4.62	-	-	5.0	-	-
ii) Transplanted local	9.66	28	120	8.12	29	107	4.75	40	86
iii) Transplanted HYV-Rainfed.	-	-	-	1.33	120	75	3.20	130	189
Boro i) Local	1.60	34	25	1.10	35	17	1.00	50	32
ii) HYV.	0.58	130	34	1.33	150	91	2.30	175	183
Rice Total:	25.48		220	23.79	[illegible]	229	26.20		768
B. Wheat:	0.30	10	1	0.30	10	1	0.50	25	6
Foodgrain Total:	25.78	221	221	24.09		330	26.70		774
C. Sugarcane.	0.40	73	13	0.38	73	13	0.40	120	22
D. Jute.	2.54	22	24	2.26	22	23	2.54	40	46
E. Other crops except tea.	3.86	5	19	4.10	5	9	4.20	8	15
Total crops other than tea(Urea,TSP,& MP)	32.58		277	31.23		375	33.65		857
F. Tea(ASP only)	0.10	291	[illegible]	0.10	145	7	0.11	300	15
G. NPK ratio.	100:	32:	10	100:	32:	9	100:	38:	12
H. Projected Use by type of fertilizer: Urea.			196			270			583
Triple superphosphate			66			87			222
Metriate of Potash.			15			18			52
Ammonium sulphate.			13			7			15

TABLE: III: PROJECTED FERTILIZER USE IN BANGLADESH (.000 TONS)

	1982-83 Fertilizer use Area million acres.	1982-83 Fertilizer use Rate lb/acres.	1982-83 '000' tons.	1992-93 Fertilizer use Area million acres.	1992-93 Fertilizer use Rate lb/acres.	1992-93 '000' tons.
A. Rice						
Aus i) Broadcast local.	3.50	20	32	2.50	25	28
ii) Broadcast.HYV	4.50	120	245	4.50	130	265
iii) Transplanted	0.60	175	48	1.00	185	84
Aman i) Broadcast.	4.50	-	-	4.00	-	-
ii) Transplanted local.	2.25	50	51	1.50	55	37
iii) Transplanted HYV-Rainfed.	4.50	140	286	3.00	150	204
Boro i) Local.	0.85	60	23	0.70	70	22
ii) HYV.	3.00	200	272	5.00	200	454
Rice total:	26.45	[illegible]	1,232	27.20		1,514
B. Wheat:	0.70	60	19	1.00	80	36
Foodgrain total	27.15		1,251	28.20		1,550
C. Sugarcane.	0.45	150	31	0.45	200	40
D. Jute.	2.80	60	76	3.00	80	109
E. Other crops except tea.	4.50	10	20	4.50	15	31
Total crops other than tea (Urea,TSP & MP).	24.00		1,321	25.95		1,730
F. Tea(ASP only)	0.12	312	17	0.13	339	20
G. NPK ratio.	100:	42:	14	100:	45:	16
H. Projected Use by type of fertilizer: Urea.			866			[illegible]
Ttriple superphosphate			364			496
Metriate of Potash			91			132
Ammonium Sulphate.			17			20

TABLE -IV : BANGLADESH FERTILIZER NEEDS AND PRODUCTION ACCORDING TO PRESENT PLANTS (IN '000' TONS)

Nutrient		1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83
Needs	Nitrogen(N)	136.1	171.7	207.2	242.7	278.3	291.3	304.3	317.3	330.3	343.3
	Phosphate(P_2O_5)	45.1	73.5	101.8	130.2	158.6	168.9	170.2	209.6	200.0	210.3
	Potash(K_2O)	14.9	29.9	45.0	60.0	80.4	80.4	80.6	90.9	96.1	101.4
	Total needs ($N+P_2O_5+K_2O$)	196.1	279.1	354.0	432.9	512.0	540.6	569.1	597.8	626.4	655.0
Production											
	Nitrogen(N)										
	Banchuganj	20.5	27.5	27.0	26.5	26.6	25.6	25.2	24.7	24.3	23.8
	Ghorasal	89.5	91.4	93.1	94.5	96.3	97.6	99.5	100.5	103.9	105.7
	Ashuganj (planned)	-	-	-	-	-	[illegible]	135.0	137.7	140.4	143.1
	Total(Nitrogen).	110.0	118.9	120.1	121.0	122.4	135.7	159.7	263.2	267.3	270.8
	Phosphate(P_2O_5) Chittagong.	-	36.8	39.2	39.6	40.5	40.9	47.3	42.3	43.2	43.7

TABLE - V : PROJECTED PRODUCT NEEDS FOR FOOD GRAINS AND MAJOR CROPS ('000' TONS).

Crops	1978-79				1983-84			
	Urea	TSP	MP	Total	Urea	TSP	MP	Total
Rice	594	342	112	1,048	730	452	152	1,334
Wheat	12	77	2	21	15	9	3	27
Sugarcane	11	10	10	31	10	8	10	28
Jute	4	1	1	6	4	1	1	6
Other crops	1	1	1	3	11	7	5	23
Total	622	361	126	1,108	770	477	171	1,418

80 per cent of the rated capacity provided, as already indicated, major modification and improvements are effected. The phosphatic fertilizer manufacturing units will be in a position to achieve an average performance of 56 to 74 per cent of the rated capacity.

VI. Future Programme.

The gap between current production levels and needs as compared to projected productions from existing plants indicate that additional local manufacturing facilities shall have to be set up. Although this is conditioned by such factors as availability of raw material from indigenous sources vis-a-vis import requirements and resource constraints, large deposits of natural gas (Table -VI) suggest setting up of more nitrogenous fertilizer plants, while foreign trade balances recommend at least one more phosphatic manufacturing facility. Current [illegible] for two new nitrogenous fertilizer plants, one at Ashuganj as part of a Petrochemical Complex, and one at Shatnol for initial export to India, to be absorbed locally as demands grow. More export oriented urea plants may also come up to improve balance of payments position since the gas is there. One more phosphatic fertilizer plant, preferably di-ammonium phosphate, is expected to be set up following detailed studies now under way. Any environmental study of the Bangladesh fertilizer plants has therefore, to take into account the five existing facility, so that the adverse effects of pollution as had been manifest in these plants could be minimised.

VII. Pollution Hazards.

Even though the call for a reduction of pollutants in waste water discharges by regulatory agencies and the public has led many industries to employ water reuse and reclamation techniques in the developed countries, and to some extent in some developing countries as well, such ecological treatment has not at all been practised, until recently, in Bangladesh.

TABLE VI : Quantity and Analysis of Natural Gas in Bangladesh [illegible]s.

Figures in million million (Trillion) Cft.

	Rashidpur	Kailas Tila	Titas	Habiganj	Haripur	Chhatak	Bakhrabad
Provon	0.47	0.38	0.95	1.00	0.439	0.02	Preliminary estimate
Probable	0.18	0.15	0.90	0.19	-	-	3.70
Possible	0.41	0.07	0.40	0.09	-	-	-
Total Quantity (million million) cft.	1.06	0.60	2.25	1.28	0.439	0.02	3.70
Composition (Vol %)							
Mothano	98.2	95.7	97.2	98.8	95.4	99.05	95.2
Ethano	1.2	2.6	1.8	1.5	2.67	0.25	1.4
Propane	0.2	0.9	0.5	-	0.30	-	0.8
Butane and higher Hydrocarbon	0.1	0.4	0.2	-	0.79	-	0.3
Nitrogen	0.3	0.2	0.3	0.7	0.37	0.67	0.4
Carbon monoxide	-	-	-	-	-	-	1.6
Carbon Dioxide	-	0.2	-	-	0.48	0.04	0.6
Hydrogen Sulphide	-	-	-	-	-	-	-
Calorific value (Btu/Cft)	1014	1050	1039	1020	1052	1007	1022

The primary reason for this is that more attention was rightly given towards sustaining a reasonable operating efficiency to provide the much needed fertilizer to the economy. There had been only one nitrogenous fertilizer plant at Fenchuganj which went into operation in 1962 until the Chorasal plant went into operation in 1972. The effects of effluents on surrounding crops and fishes, whenever reported, were minimized by diluting the effluents through addition of huge volumes of fresh water to the harmful effluents.

The other, and perhaps more pronounced, reason was the absence of any knowledge of the pollution hazards associated with effluent disposal from fertilizer plants. Much of the pollution load is associated with the suspended solids contained by the waste stream, and may be removed by clarification with or without chemical treatment. Soluble organic wastes generally cannot be treated sufficiently by clarification and chemical precipitation alone, but they are often amenable to treatment by microorganisms. Provesses involving the use of bacteria and other miorobes for the stabilization of wastes are called biological oxidation treatment and are sometimes referred to as secondary treatment steps. The most popular treatment methods are the acrobic systems which require a supply of oxygen for the bacteria so they may consume food (organics) to produce carbon dioxide, water, energy and new cells. In these systemsms much of the carbon is oxidized to carbon dioxide and the nitrogen and sulphur to nitrates and sulphates. The solids which accummulate are settled out in a clarifier and consist for the most part, of the bacterial calls produced by synthesis. A variety of organic materials escpecially those which exhibit bio-chemical oxygen demand may be decomposed or stabilized with respect to biological degradation by microbial processes, that is by microflora and fauna. In contrast, inert products are not biologically degradable so disposal of such materials ordinarily becomes a solids-waste problem instead of a waste stabilization problem.

Ammonia and its salts are of interest in water-pollution and water quality studies because ammonium compounds are generally detrimental or lethal if more than 2.5 ppm of ammonia are present because more than 1 ppm of ammonia in natural waters usually points to organic pollution, and because many of the lower plants and bacteria that are involved in the food chains upon which fishes depend can utilize ammonia as a source of nitrogen. The toxicity of ammonium compounds depends chiefly upon the amount of ammonia [illegible] available but also upon the alkalinity of the water carrying the ammonium salt. Although detrimental effects may be expected if 2.5 ppm or more ammonia are present in the water many fishes, particularly carp buffalo and some sunfishes can tolerate from 3 to 10 ppm of ammonia.

The toxicity of ammonia and ammonium salts to aquatic animals is directly related to the amount of undissociated ammonium hydroxide in the solution which in turn is a function of PH. Thus a high concentration of ammonium ions in water at a low PH may not be toxic but if the PH is raised toxicity will probably increase. The toxicity of a given concentration of ammonium compounds towards fish increases by 200 per cent or more between PH 7.4 and 8.0.

The presence of carbon dioxide upto concentrations in the range of 15 to 60 mg/1 appears to reduce the toxicity of ammonia presumably by lowering the PH value. In as much as carbon dioxide is excreted by the fish, the PH value at the gill surface will be lower than in the bulk of the solution, thereby reducing the proportion of un-ionized ammonia at the gill.

The toxicity of ammonia to fish is increased markedly at low tensions of dissolved oxygen. The concentrationof excreted carbon dioxide at the gill carbon dioxide is also reduced and the PH value of the water in contact with the gill surface rises, leading to an increas ed toxicity of an ammonia solution. This mechanism explains the increased toxicity of ammonia at low oxygen tensions. The following concentration of ammonia have been reported to be toxic or lethal to fish in the time specified:

Concentration NH_3 in mg/l	Time of exposure		Type of fish
0.3-0.4	-		trout fry
0.3-1.0	-		fish
0.6 (un-ionized)	100-200 minutes		rainbow trout
0.7	390 minutes		rainbow trout
1.0-2.0	-	xx	fish
1.2	193 minutes		squalius cephalus
2.0	-		fish
2.0-2.5	1-4 days		goldfish
2.5	1-4 days		goldfish
2.0-7	-		fish
2.9	13 hours		Cichla ocellaris
3.1 (soft water, 30°C)	96 - hour	bluegill, sunfish	
3.4 (soft water, 20°C)	96 - hour	bluegill, sunfish	
5.0	-		rainbow trout
5.7 (distilled waters 20°C)	6 hours		minnows
7-8	1 hour		sunfish
13	-		fish
17.1	1 hour		minnows
23.7(hard water, 30°C)	96-hour TLM		bluegill, sunfish
24.4(hard water, 20°C)	96- hour Tlm		bluegill, sunfish
75.7	less than 4 minutes		trout.

With respect to other aquatic life, the following results have been reported by the Academy of Natural Sciences of Philadelphia as quoted in Water Quality Criteria published by the California State Water Quality Control Board:

Organism	Time of exposure	Type of water	Temperature °C	Concentration of NH_3 as N in mg/l producing noted effect
Physa heterostropha (snail)	96-hour	Soft	20	90 (a)
		hard	20	133.9(a)
		soft	30	94.5(a)
		hard	30	133.9(a)
Nivicula seminulum (diatom)		soft	22	420(b)
		hard	22	420(b)
		soft	28	320(b)
		hard	28	420(b)
		soft	30	410(b)
		hard	30	350(b)

(a) 96-hour TLm

(b) 50-per cent reduction in division (growth)

Algae, which thrive on high nitrate concentration, appear to be harmed or inhibited when the nitrogen is in the form of ammonia. The environmental situation of the fertiliser plants in Bangladesh may be evaluated in this ecological backdrop.

VIII. Environmental situation.

The environmental situation of the Fenchuganj Fertiliser plant is not concerningly relevant as that of the Ghorasal plant since it is located in an isolated place, and, after twelve years of operation it may be expected to have adopted adequate measures to minimise the effects of effluent on fish, the prime indigenous source of protein for most of the population in Bangladesh. This discussion is, therefore, limited to the nitrogenous fertilizer plant at Ghorasal, the phosphate plants are yet to go into operation to allow any evaluation of their effluents.

The Ghorasal fertilizer plant is located on the bank of river Sitalakhya about twenty-eight miles from the capital Dacca. Upstream there are two miles on the same bank, one jute mills adjacent to it, and one sugar mills, while downstream there are two thermal power station one the 132 MW Ghorasal Power plant, adjacent to, and the other the 90 MW Siddhirganj Power Station, about 30 miles from the factory, and a good number of jute mills on either side of the bank. Effluent disposal from this factory is a great problem as it contains ammonia, which, besides being toxic to aquatic animals, will be harmful to heat exchangers of the two power plants, particularly the one adjacent to it.

The obvious pollution hazards from the factory are the catalysts supporting the process, the chemicals used to treat the various kinds of water used in the factory, and the ammonia which is an intermediate production in the production of fertilizer. Arsenic used in the carbon dioxide absorption appears the most dangerous of the catalysts.

The factory uses four kinds of water which it makes from river water. Raw water from the river is fed into a settling tank whence, after settling heavier impurities , water is made to flow into clarified unit for treatment where alum, chlorine and soda ash are injected. This treated water is used for direct cooling purposes. The clarified treated water is filtered by passing through the filterbeds containing sand and anthracite. This fillered water is used as colling water make-up in heat exchangers and orgafilm and chlorine are injected in the circulating cooling water. The treated and filtered water is further treated in cation and an-ion exchange resin beds and decarbonator.

This pure water after deaeration is fed into the boilers after hydrazine has been added. Phosphate is injected in the boilers. This pure water is used for 13 Kg/m^2 g steam generation Pure water and condensate from steam turbine is further treated in mixed bed, both cation and an-ion exchange resins. This polished water is deaerated and fed into the boiler after adding hydrazines phosphate is injected into the boiler. The polished water is used to generate 100 Kg/m^2 g steam.

Production of each of these four kinds of water produces wastes which may pollute river waters. Waste from the production of 'treated' and cooling water are merely concentrated mud from the river with addition of some alum and are not likely to be hazardous to a river as the Sitalakhya. In the production of 'pure' and 'polished' water, the chemicals used to regenerate the ion exchange resins can be a hazard to streams. The principal one of these chemicals is sulphuric acid which can be very harmful if discharged in larger amounts without neutralisation. Hydrazine used in the boilers and "orgafilm-used in the cooling water could also be hazardous if discharged to the river. Orgafilm is a combination of potassium chromate and a glassy phosphate. Four hundred tons of cooling water are added to the cooling tower hourly. Most of this evaporates, leaving the natural salts and hardness in the water behind. These salts will build up to high concentration if part of the cooling water is not emptyied out periodically. Emptying several thousa-nd tons of water containing potassium chromate (and occasinally chlorine) into the river could be hazardous to aquatic animals.

IX. Minimising Pollution.

However the principal water pollution from this factory is from ammonia in the effluent disposed into the river. Apart from this urea dust and purged ammonia gas pollutes the environment as well.

Since, however, the effect of water pollution is more pronounced primarily because of the possible effect it may have on the downstream plants, the basis for design for water effluent to the river has been set as under :

PH	6.0 - 9.0
Colour	clear
Oil	50 ppm maximum
Arsenic	0.1 ppm
H_2S	0.2
Biological Oxygen Demand (BOD)	20 ppm max, (Biological demand $20^{\circ}C$ 5 days)
Total suspended solids :	30 ppm maximum
Total dissolved solid :	1000 ppm maximum.
Ammonia :	20 ppm (as N) maximum.
Temperature :	$35^{\circ}c$ maximum.
Odour :	Free.

The average monthly effluent water analysis over the last one year is given in Table VII. It would be seen that the effluent going into the river contains very high proportion of ammonia. The reason for these large ammonia discharges is regular drainage of cooling water with high ammonia concentration from ammonia and recycle solution plunger pumps. These waters contain ammonia as high as 18,000 and 58,500 ppm respectively. Total volume of water is about 35 tons per hour and it has been found in laboratory tests that if this water is boiled at $105^{\circ}c$ in open air for about three hours ammonia content is reduced to about 240 ppm. Similar leakage of ammonia occurs from the glands of slurry, circulation, booster and absorbent pumps and suction and purge line of recycle solution pump carried by washing water due to valve leakage, with ammonia concentrations varying from 43 to 3640 ppm. These leakages from the pump glands and purge lines can be reduced to a minimum if the

TABLE VII : MONTHLY AVERAGE EFFLUENT WATER ANALYSIS OF GHORASAL FERTILIZER PLANT

Month	Total Effluent to River (Drain Sample)		200 yds downstream (Middle)		200 yds Downstream & (River-bank)	
	PH	Ammonia(ppm)	PH	Ammonia(ppm)	PH	Ammonia(ppm)
1973 May	9.00	250.0	7.88	1.49	-	-
June	8.20	48.3	7.77	0.46	-	-
July	7.68	0.9	7.57	0.78	-	-
August	9.11	433.5	7.87	1.79	8.10	5.32
September	9.00	492.8	7.80	3.71	-	-
October	9.82	444.0	7.80	2.55	-	-
November	9.15	394.5	8.23	8.58	-	-
December	9.40	401.0	8.00	7.45	8.10	11.23
1974 April	8.50	223.7	7.60	3.08	8.09	3.57
June	9.25	209.0	7.96	1.95	8.23	5.30
July	9.29	94.0	7.61	0.909	7.56	2.12

over-flowing liquid from the vacuum pit could be so treated as would decompose carbamate and properly separate the gas coming from the reaction by maintaining optimum conversion in reactors and maintaining proper temperature is high pressure and low pressure decomposer and gas separator.

These operational remdial measures apart, additional measures are being taken to minimize pollution from the fertilizer plant. These include construction of one sump touk with a handling capacity of 60 tons per hour with a centrifugal pump where all the effluent is to be diverted fo proper dilution before discharge. Further one evaporator is to be installed with steam jacket and a level controller to evaporate ammonia from the effluent under reduced pressure. The effluent after evaporation is to be sent to a lagoon which is to be made outside the factory battery limit.

Simultaneously, bio-assay are to be run rontinely to establish the water pollution hazard of the factory. Arrangements are to be made to run a measured amount of factory effluent through the test tanks continuously with diluent water, which may be river water taken from the river pump discharge, or treated water. The proportion of diluent water could be increased or decreased depending on the quality of effluent.

Besides, ammonia in the effluent is proposed to be removed and recovered by ion-exchange, adopting a process developed at the natural gas-based urea plant at Namrup in India, where ammonia content in the effluent averaged about 1000 ppm creating a major pollution problem. In the process, which involves treatment with sulphuric acid using a cat-ion exchange resin, the effluent will be collected in a storage tank from which it will be pumped through two cat-ion exchangers working in series. The ammonia absorbed in the first exchanger will be recovered as ammonium sulphate by regeneration with sulphuric acid in the form of 13 to 15 per cent ammonium sulphate solution containing about 1 to 2 per cent sulphuric acid. The effluent after this treatment will contain negligible amount of ammonia which can be easily disposed off. This recovery may also represent substantial credit to the overall cost of water and waste handling.

X. Conclusions.

Much of the pollution effects from nitrogenous fertilizer plant in Bangladdsh relate to operational failures and improper maintenance and hence can be greatly reduced if adequate corrective measures are taken. Preventive maintenance measures will greatly help in eliminating leakages and overflows from pump glands, pits. Water reuse, either with or without chemical and biological treatment should be practiced whenever possible. The possible savings in waste treatment should be investigated. While today's sewer costs may be low, growing governmental regulations will make waste treatment mandatory. It is also realistic to design waste disposal and treatment facilities to meet future regulatory standards one to five years hence, as they will undoubtedly become stringent. The basis of bio-chemical oxygen demand, nitrogen, phosphate and suspended solids levels in addition to the volume of waste water will be the main criteria for consideration in future. The process flowsheets should be reviewed to determine where and how these levels can be built most economically. The most important thing, however, is that significant savings can potentially be achieved while lowering the cost of water in waste water treatment in the process industries.

The problem of pollution will never be any greater than it is at the present time. The perceptive plant engineer should anticipate the needs of the future and take steps to correct the important pollution problem than to handle it in a less economic way sometime in the near future. When considering the design of new plants, the waste water and wate r reuse processer as well as waste-recofery should be considered as part of the entire plant scheme to minimize, primarily, pollution hazards and any future capital operating costs . This is of particular significance for Bangladesh in view of the planned and potential fertilizer production facilities.

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