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BENCHMARKING OF EMISSIONS FROM NITROGENOUS FERTILIZER PLANTS: INDIAN EXPERIENCE[1]

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SUMMARY

FAI, which acts like a bridge between the Government and Industry has been keeping track of the efforts made by the fertiliser industry towards complying with Environmental Protection Standards and also improving the environmental performance. In order to assess the environmental performance of fertiliser plants, FAI devised its own internal benchmarking mechanism. This paper covers our experience of benchmarking of the overall environmental performance of ammonia-urea plants in India. Comparative assessment has been made using individual environmental parameters like energy consumption, carbon dioxide emission, ammonia consumption for urea production, water conservation, urea dust emission and total nitrogen in waste water discharge.

RESUME

The Fertiliser Association of India, FAI, en faisant la liaison entre le gouvernement et l'industrie des engrais, a suivi les efforts de l'industrie des engrais pour respecter les normes de protection de l'environnement et également pour améliorer leurs performances environnementales. Afin d'évaluer les performances environnementales des unités de fabrication des engrais, la FAI a conçu son propre système de références (benchmarking). L'exposé traite des expériences concernant le "benchmarking" de l'ensemble des performances des unités d'ammoniac-urée en Inde. Une évaluation comparative a été faite en utilisant certains facteurs liés à l'environnement tels que la consommation de l'énergie, l'émission du dioxide de carbone, la consommation de l'ammoniac pour la production de l'urée, la conversion de l'eau, l'émission de poussière de l'urée et l'écoulement de l'azote totale dans l'eau.

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Introduction

India is the third largest producer and consumer of fertilizer in the world. There are 57 major nitrogenous and NP/NPK complex fertilizer plants besides 83 single super phosphate plants with an installed capacity of 10.518 million tonnes of N and 3.135 million tonnes of P_20_5. These plants produced 10.083 million tonnes of N and 3.058 million tonnes of P_20_5 during 1997-98. The growth and development of Indian fertilizer industry since 1950 is given in Table 1; there has been a spectacular growth and development during the 70's and 80"s. The installed capacity of N and P_20_5 increased by 6.798 million tonnes and 2.281 million tonnes respectively, while the production increased by 6.160 million tonnes of N and 1.822 million tonnes of P_20_5.

During the same period i.e. the early 70's the environmental movement in India gained momentum. The first legislation pertaining to Water was promulgated in 1974 followed by the Air Act in 1981 and the Environmental (Protection) Act in 1986. As per universal practice, Environmental Protection Standards were prescribed for various industries under these Acts. From mid 80's, the Government started enforcing the standards in all seriousness to preserve/protect the environment.

India has a total of 35 urea plants with integrated ammonia plants. These plants produced 18.594 million tonnes of urea during 1997-98 which constitutes about 85% of the total nitrogenous fertilizers produced in the country. During 1988 only 13 of these ammonia-urea plants were able to comply with environmental protection standards, while today almost all plants barring few sick units are complying with environmental protection standards. Attaining this status was made possible by keeping pace with the technological advancement taking place elsewhere in the world. The technological advancement and improved design features helped the plants set up in the 80's to incorporate in built pollution control measures to minimise pollution. However, the options available to older plants were limited to developing and incorporating add on pollution abatement measures. The Government on its part constantly interacted and reviewed the progress

[1] *Bases de références des émissions provenant des unités d'engrais azotés : expérience indienne*

made by the industry and recognised the genuine problems/practical difficulties faced by the industry in implementing the standards. The net result was stipulation of two different set of standards for plants commissioned before 1st January,1982 and another for plants commissioned after 1st January 1982 for ammoniacal nitrogen, total nitrogen and urea dust.

Benchmarking of the Overall Environmental Performance of Fertilizer Plant

The FAI, which acts as a bridge between the industry and Government, kept track of the progress made by the fertilizer industry and problems faced by them. In order to assess the environmental performance of the fertilizer plants, FAI devised its own internal benchmarking mechanism. This paper covers our experience in this benchmarking exercise. For the purpose of benchmarking, an elaborate proforma was drawn. The data collected through this proforma from the fertilizer plants formed the basis of our benchmarking exercise and was started way back in 1988-89. Initially each plant was assessed by comparing its environmental performance with respective environmental protection standards wherever applicable and also with other plants. This was translated into scores by giving weightages. To encourage the plants to continuously improve its environmental performance, the plants which scored the highest score was declared the best Environmental Performance Plant. The above benchmarking exercise is illustrated further in the following paragraph.

During the year 1996-97 data was collected from 21 ammonia-urea plants. These plants were compared/benchmarked on every relevant environmental parameters classified under four broad heads, namely:

i) Water conservation:
Where in parameters benchmarked are water consumed and waste water discharged.

ii) Improvement in nitrogen
Here in the specific NH_3 consumption for recovery efficiency: urea production is compared with design specific consumption.

iii) Environmental quality improvement:
Herein the parameters benchmarked are total nitrogen, chromium, urea dust, ambient air quality. Weightages are allocated for reported noise level, solid waste generation and mode of disposal, etc.

iv) Environmental management:
Herein fixed weightages are allocated for: development of green belt, tree plantation, accident from operation, monitoring of pollutants, training of employees, organisation of mass awareness programme, new pollution abatement measures implemented during the year, etc.

Figure 1 shows the environmental ranking of these 21 plants, wherein various environment parameters were compared with environmental protection standards wherever feasible and the other parameters were compared with each other. The weightages given were on relative basis i.e. for example the least water consuming plant was given the highest marks, while the highest water consuming plant was given the least marks and the other plants were allocated weightages in between. 14 plants have scored above 80%, while 6 plants have scored above 70%. This system of ranking was used initially to promote resource conservation and compliance with environmental protection standards. By early 90's most of the fertilizer plants barring sick units complied with Environmental Protection Standard. So to induce the plants to improve its own performance beyond mere compliance with Environment Protection Standards and also approach the environmental performance of better/best plant, the plants were assessed by comparing their performance with other plants. Further the plants were also assessed on the basis of the improvement they have made over the previous two years and the magnitude of the improvement made.

Figure 2 shows the ranking of the same 21 plants for the same year on this basis and the scores of these plants have come down. This does not mean that the environmental performance of these plants are not satisfactory. These plants are all performing better compared to the Environment Protection Standard. However, there is still scope for these plants to improve their own performance and approach the best environmental performance plant. Also the relative magnitude of its improvement over previous year was lower.

This system of ranking even induced the plants showing good environmental performance to do better, while the average performance plants were encouraged to reach the performance of better operating plant. Having done the overall benchmarking of these plants, it is necessary to consider the benchmarking of individual environmental parameters like, energy efficiency, water conservation, emissions, etc.

Benchmarking of the Individual Environmental Parameters

Energy Consumption

Since energy efficiency contributes significantly towards resource conservation and also is directly related to CO_2 emissions, benchmarking of energy consumption of various plants has also been carried out separately and dealt with. The weighted average energy consumption per tonne of ammonia and urea registered progressive reduction over the period 1990-91 to 1996-97. The average energy consumption reduced by 0.66 million KCal/tonne of ammonia and 0.73 million KCal/tonne of urea respectively during this period. The energy consumption of individual ammonia and urea plants based on gas, naphtha and fuel oil during 1990-91 to 1996-97 is given in Figures 3 and 4 respectively. While the weighted average energy consumption of gas based plants improved by 0.36 million KCal/tonne ammonia during 1990-91 to 1996-97, it can be seen from Figure 3 that the percentage of total production based on gas consuming energy less than 8.5 million KCal has increased from 46% to 64% during the same period. Amongst the naphtha based plants, the percentage of total production consuming energy less than 11 million KCal/tonne remained almost the same during this period although the weighted average energy consumption of naphtha based plant improved by 0.63 million kilo calories. The percentage of total production based on fuel oil consuming less than 14 million KCal/tonne of ammonia during the same period increased from 40% to 78% while the weighted average energy consumption of fuel oil based plant improved by 1.05 million KCal. From the above it may be concluded that energy efficiency of a large number of plants have shown marked improvement.

Similarly during the same period urea plants categorised on the same basis of the associated ammonia plants being based on gas, naphtha and fuel oil improved their energy consumption by 0.87, 0.21 & 0.42 million KCal respectively.

Carbon dioxide (CO_2) Emission

It is well known that CO_2 gas is responsible for climatic warming and the onset of green house effect and is primarily emitted from the burning of fossil fuel. However, we started collecting data on CO_2 emitted by the fertilizer plants only recently and as such we have data pertaining to only about 19 fertilizer plants. As a consequence we compared the CO_2 emitted per tonne of ammonia over 1990-91 to 1996-97. The CO_2 emitted per tonne of ammonia excluding the quantity used for urea production or other use is given in Figure 5 and shows a declining trend in line with reduction in the weighted average energy consumption of ammonia plants during the same period. This data is very difficult to interpret. However, considering the fact that most of the new gas based capacities have been using naphtha and fuel oil either partially or totally as fuel, the decline in CO_2 emission is a welcome positive step.

Ammonia Consumption in Urea Production

Closer the specific consumption of ammonia (for urea production) to the design value the lesser the plant losses to the environment. Consequently, the specific ammonia consumption for urea production have been benchmarked. The weighted average specific consumption of ammonia for urea production improved from 0.589 tonnes/MT of urea to 0.584 tonnes/MT of urea during the period 1990-91 to 1996-97. Individual plant data shows that during 1996-97 eight plants were operating at or lesser than the designed specific consumption as compared to only two plants during 1990-91. Also barring three plants all other plants improved their specific ammonia consumption during the period 1990-91 to 1996-97.

Water Conservation

Fertiliser industry is water intensive. For a developing country like India, conservation of water is very important. In fact scarcity of water experienced by several plants over the years has adversely affected their production performance. Also the cost of fresh water and its treatment besides effluent treatment cost has also been escalating. Consequently, fertilizer plants made continuous and concerted efforts to conserve water and promote its efficient use.

Ammonia-urea plants as a whole conserved about 12% of water during the period 1990-91 to 1996-97. Analysis of water consumption data of gas, naphtha and fuel oil based plants indicate that naphtha based plants conserved 21% water while gas based plants conserved about 15% of water. The performance of fuel oil based plants as a whole showed deterioration. Figure 6 shows the water consumption data of individual plants based on gas and naphtha for the period 1990-91 to 1996-97. Comparison of the water consumption data of various plants during this period shows that all gas based plants barring 2 plants improved their water consumption. Amongst the naphtha based plants 6 out of 9 plants improved their water consumption. One of the naphtha based plants in fact conserved 11.4 cubic meter/tonne of urea during this period. The performance of only 2 out of 5 fuel oil based plants showed improvement.

The waste water discharged by the ammonia-urea plants reduced by 14%. It can be seen from Figure 7 that the waste water discharged by most of the ammonia-urea plants based on gas and naphtha were well within the Environment Protection Standard of 5 cubic meter/tonne of urea even during 1990-91. During the period 1990-91 to 1996-97 these plants by and large improved their performance further. The performance of fuel oil based plants which was within the Environmental Protection Standard of 5 cubic meter/tonne during 1990-91 and 1992-93 deteriorated and exceeded the Environmental Protection Standard limit in subsequent year. This was expected since the water consumption of fuel oil based plants had also increased and was mainly due to deterioration in the performance of two plants which need immediate measures for modernisation.

Urea Dust Emission

The urea dust emitted by plants commissioned before 1.1.1982 (old) and plants commissioned after 1.1.1982 (new) as against the Environmental Protection Standard is given in Figure 8. Even before 1992-93 all the new urea plants were emitting less dust than the Environmental Protection Standard of 0.5 kg/tonne of urea. Over the period 1992-93 to 1996-97 all of them have shown progressive improvement of their performance. The average urea dust emitted by the new plants is almost half of the stipulated Environmental Protection Standard. While all the old group of plants emitted urea dust lesser than the stipulated standard of 2.0 kg/tonne of urea, some of the old plants emit urea dust less than even 0.5Kg/te of urea i.e. the standard stipulated for new plants.

Total Nitrogen in Waste Water Discharge

There is no mass based Environmental Protection Standard stipulated for nitrogen discharged in the waste water but only 2 sets of concentration based standards; one for plants commissioned before 1.1.1982 (old) and the other for plants commissioned after 1.1.1982 (new). However, we have been collecting data from all the plants in terms of total kilograms of nitrogen discharged in the waste water. Comparison of total nitrogen discharged by old and new plants during 1992-93 & 1996-97 is given in Figures 9 and 10 respectively. One of the ammonia-urea plants does not discharge any nitrogen in the waste water since it is zero effluent discharge plant. Most of the plants showed improvement. The total nitrogen discharged by all the NH_3-urea plants in terms of kilograms of nitrogen/tonne of urea has come down from 0.567 during 1992-93 to 0.214 during 1996-97. Amongst the new plants the improvement has been only marginal because they were already attaining better standards. Comparison of the total nitrogen discharge by the new and old Indian plants with the available emission level[2] established for European fertilizer industry has been made. As against the European standard stipulated for old plants of 0.1765 kg nitrogen/tonne of urea, the older group of Indian plants discharge 0.214 kg nitrogen/tonne of urea, while the new plants discharged 0.044 kg nitrogen/tonne of urea as against the European standard of 0.0496 kg nitrogen/tonne of urea for new plants.

Considering that all the Indian older plants are commissioned on or before 1.1.1982 and several of them are old vintage plants and over 20 years old, these plants have made substantial improvement. In spite of the fact that 6 of the 10 so called new plants were commissioned prior to 1990 the performance of these plants are comparable with the European plants in respect of total nitrogen discharge in the waste water.

[2] Since three different emission levels namely; ammonia to water for ammonia and urea plants, and urea to water from urea plant have been prescribed for European fertilizer industry, for comparison purpose, we first converted this established emission levels in terms of kilogram or nitrogen/tonne of urea and then added them up to obtain the combined level of nitrogen that could be discharged into water by both ammonia and urea plants. The kilogram of nitrogen that could be discharged by ammonia-urea plants worked out to be 0.0496 for new plants and 0.1765 for old plants per tonne of urea production

On similar lines, benchmarking exercise has been carried out for complex fertilizer plants including the acid plants. We do hope that the Indian fertilizer plants would continue to improve its environmental performance till they reach the minimal emission level.

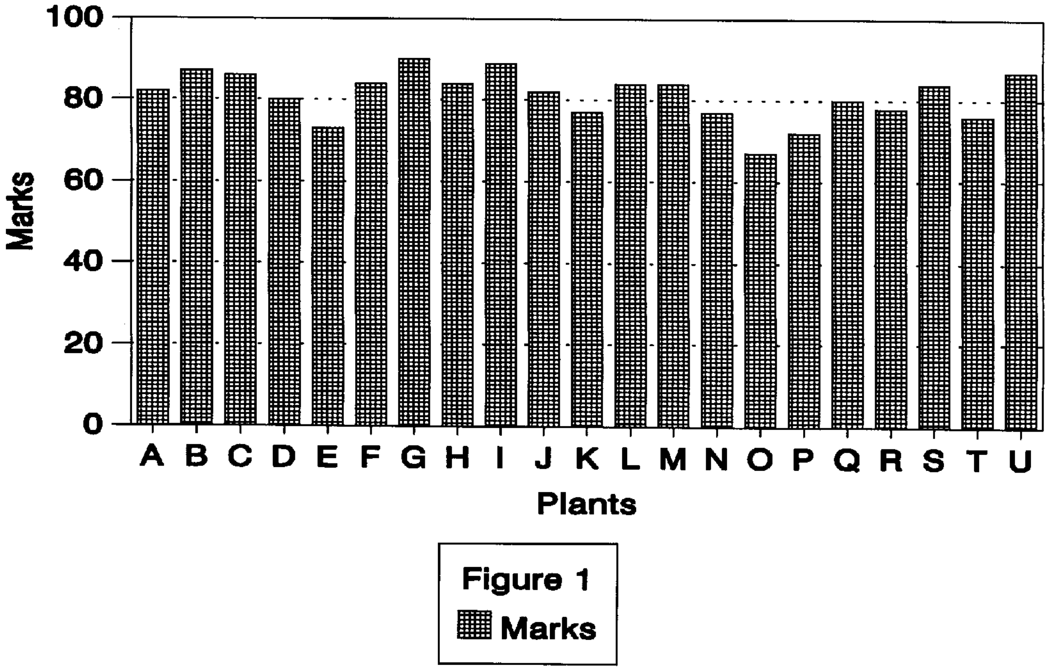
Conclusion

To encourage and induce the fertilizer plants, to improve the environmental performance, FAI started benchmarking exercise by formulating our own mechanism, 10 years back. Our efforts seems to have had a very positive effect. Almost all the plants barring sick units have improved their environmental performance over the years. Even the better performing plants have continued their efforts to improve their performance further. This exercise also provided each and every plant an opportunity to know where they stand with respect to other better performing plants.

Table 1 - Capacity and Production of N and P_2O_5
('000 tonnes)

	N		P_2O_5	
Year	**Capacity**	**Production**	**Capacity**	**Production**
1951-52	89	90	29	29
1960-61	162	112	96	547
1970-71	1,349	833	434	228
1980-81	4,586	2,164	1,330	842
1990-91	8,147	6,993	2,715	2,051
1991-92	8,282	7,302	2,806	2,562
1992-93	8,510	7,431	2,806	2,321
1993-94	8,844	7,231	2,817	1,874
1994-95	8,998	7,944	2,873	2,563
1995-96	9,134	8,769	2,982	2,593
1996-97	9,468	8,593	3,038	2,571

COMPARISON OF ENVIRONMENTAL PERFORMANCE OF FERTILISER PLANTS



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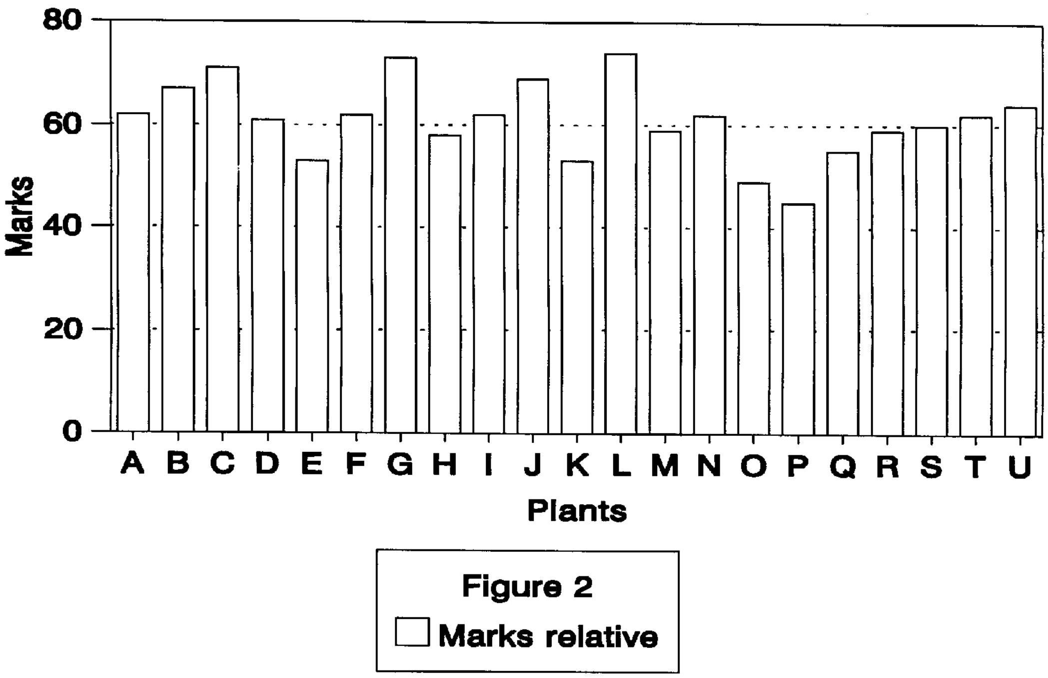

AVERAGE ENERGY CONSUMPTION - AMMONIA

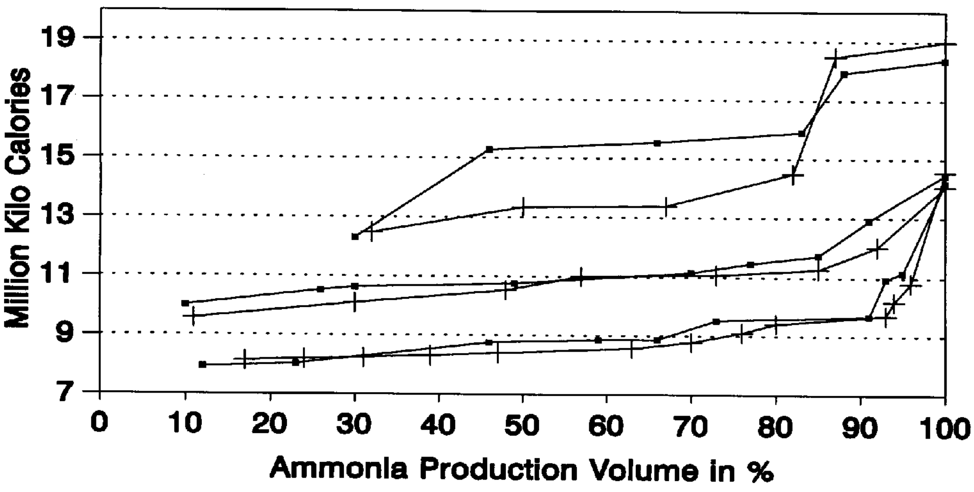

Figure 3

Gas Based 90-91 | Gas Based 96-97 | Naphtha 90-91 | Naphtha 96-97 | Fuel Oil 90-91 | Fuel Oil 96-97

AVERAGE ENERGY CONSUMPTION - UREA

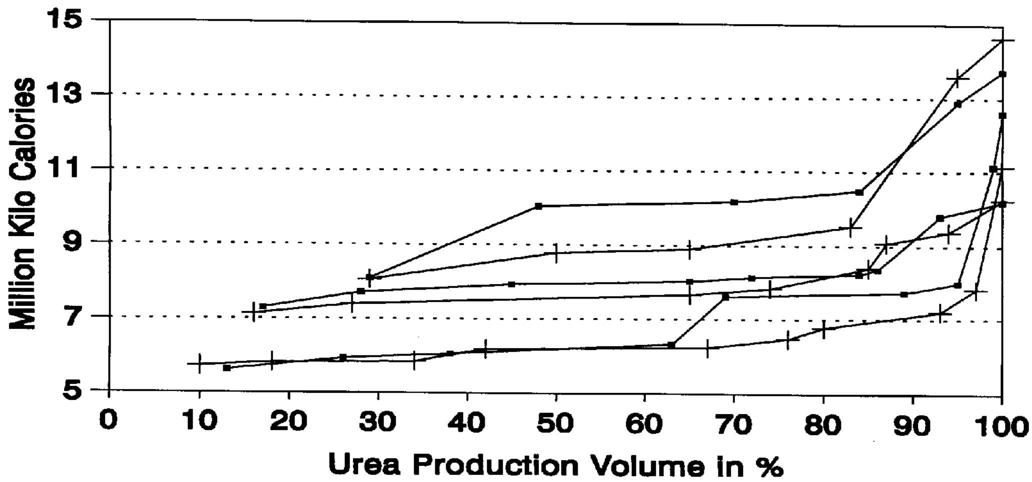

Figure 4

Gas 90-91 | Gas 96-97 | Naphtha 90-91 | Naphtha 96-97 | Fuel Oil 90-91 | Fuel oil 96-97

CO2 EMISSION

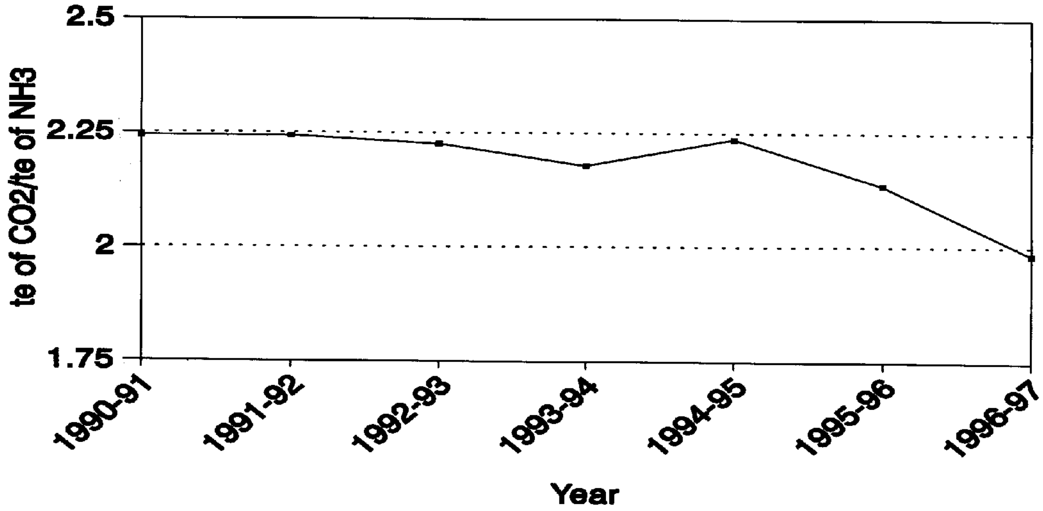

Figure 5

CO2 EMISSION

WATER CONSUMPTION

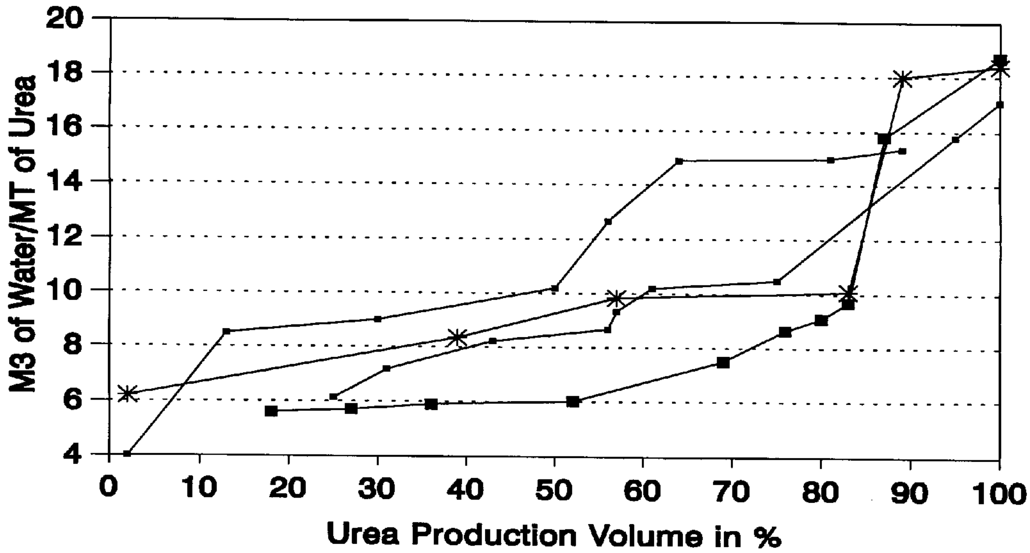

Figure 6

Gas 90-91 Gas 96-97 Naphtha 90-91 Naphtha 96-97

WASTE WATER DISCHARGE

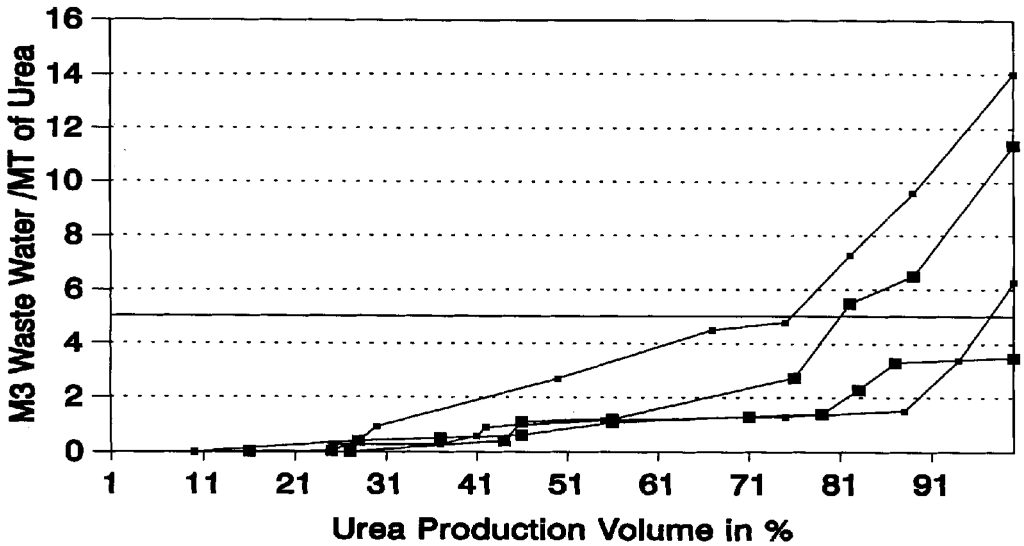

Figure 7

Gas 90-91 Gas 96-97 Naphtha 90-91 Naphtha96-97

UREA DUST

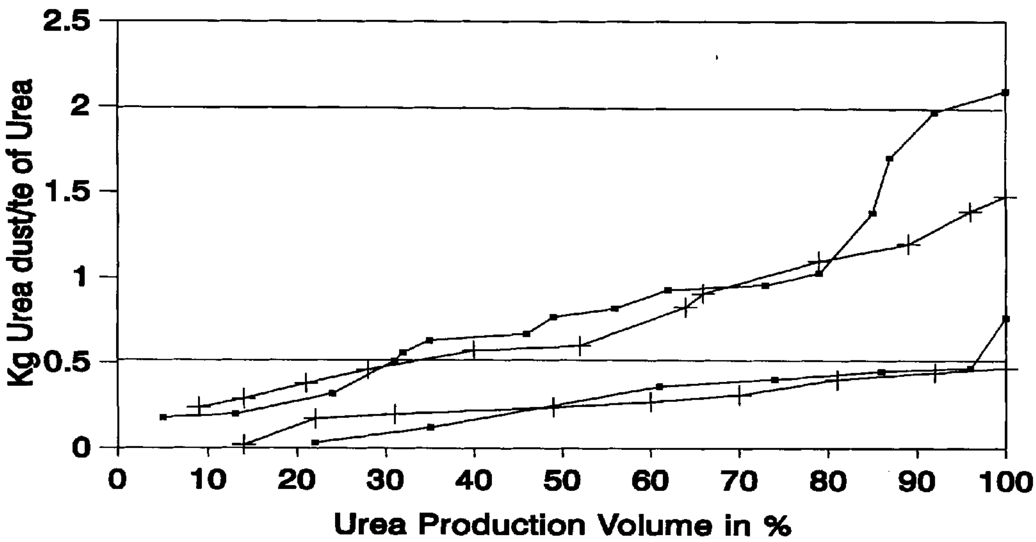

Figure 8

Old 92-93 Old 96-97 New 92-93 New 96-97

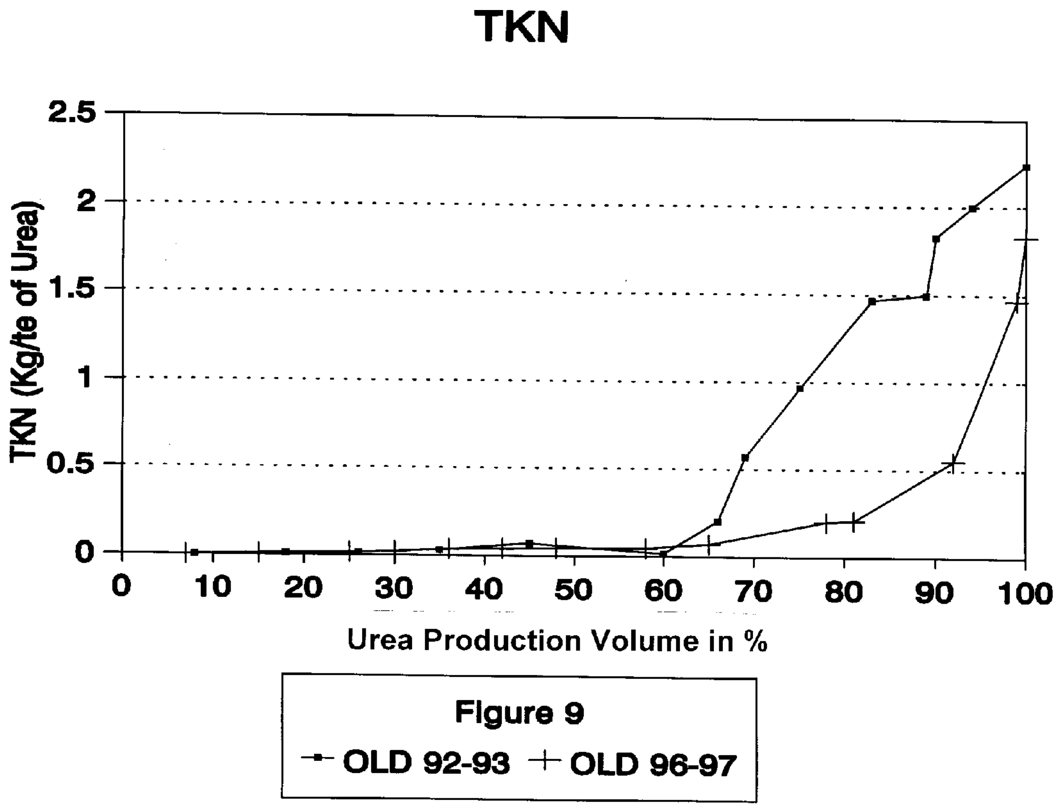

Figure 9

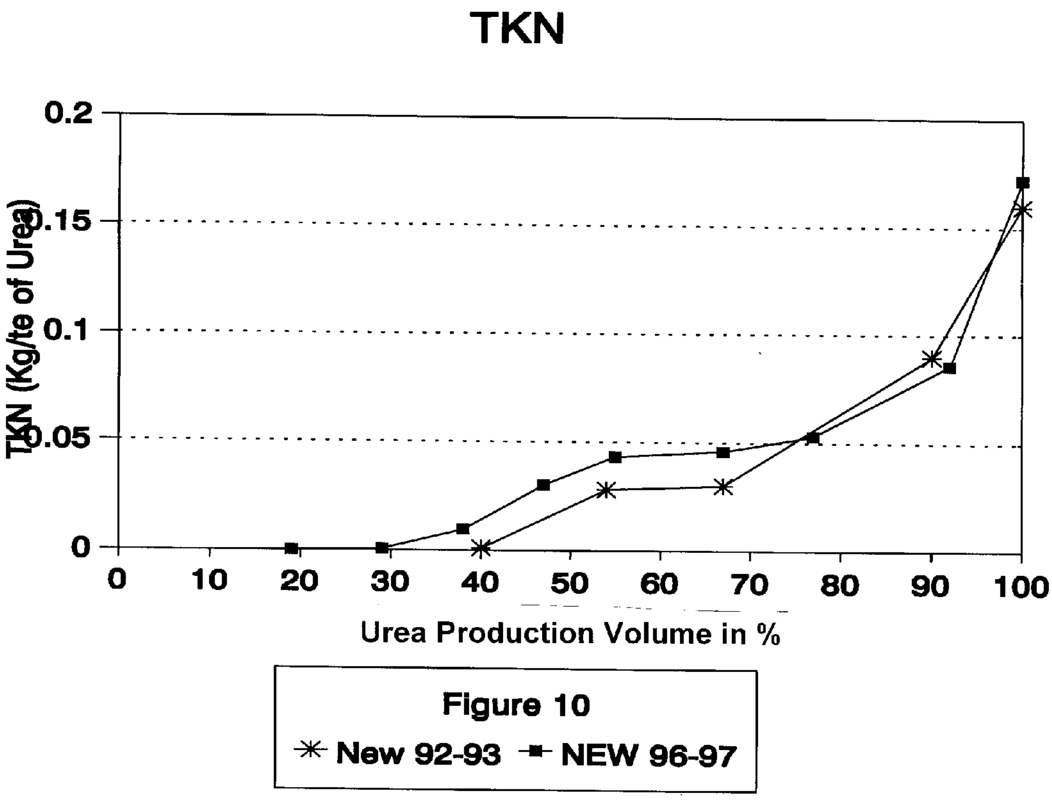

Figure 10