Parivesh

A News Letter from ENVIS Centre - Central Pollution Control Board

Editorial

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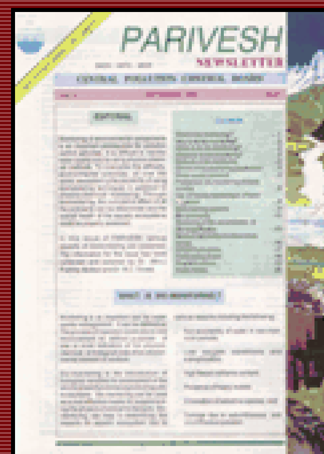

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Editorial

Monitoring of environmental components is an important prerequisite for pollution control activities. It is difficult to monitor water quality only by using physico-chemical methods. To overcome this difficulty, environmental scientists, all over the world, are exploring the possibility of using biomonitoring techniques in addition to physico-chemical monitoring. Through biomonitoring the cumulative effect of all the pollutants can be determined and the overall health of the aquatic ecosystems could be properly assessed.

In this issue of *PARIVESH,* various aspects of biomonitoring are presented. The information for the issue has been collected and collated by Dr. (Mrs.) Pratima Akolkar and Dr. R.C. Trivedi.

(Dilip Biswas)
Chairman, CPCB

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BIO-MONITORING OF WATER

WHAT IS BIO-MONITORING :

Monitoring is an important tool for water quality management. It can be defined as "the process of repeated observations and measurement for defined purposes of one more indicators of the physical, chemical or biological state of an environmental element or medium.

Bio monitoring is the introduction of biological variables for assessment of the structural and functional aspects of aquatic ecosystems Bio-monitoring can be used as a cost-effective means for supplementing the physco-chemical techniques. Bio-monitoring can help in determining the impacts of aquatic ecosystem due various reasons including the following:

- Non-availability if water in monsoon periods;
- Low oxygen conditions and eutrophication;
- High faecal coliforms content;
- Presence of heavy metals;
- Elimination of sensitive species; and
- Damage due to autochthonous and allochthonous pollution

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WHY TO DO BIO-MONITORING?

Generally, the water quality management is related to indentified beneficial uses of water in terms primary water quality criteria parameters. 'Designated- best-use' concept was evolved on the same basis. Five major uses of river water have been conceived. If a water body is put to multiple use, then the use which demands the highest quality of water is called designated-best-use and accordingly the water body or its part is designated. Measurement of chemical and physical characteristics have been used far either to detect pollution or to control it. Biological monitoring of water quality could be useful for assessing the over all health of water bodies because of the following:

- The list of chemicals to be monitored is unending.
- Biological effects often occur at concentrations below analytical capabilities. Many of the pollutants are present in such low concentrations that instrument sensitivity is too poor to determine the micro quantity of pollutants.
- The toxicants and other traces may act quite differently in mixture than individually. Such toxicants affect the ecosystem in a synergistic manner, which con not be detected by chemical analysis alone.
- Chemical nature of toxicant is highly dynamic in environment with time and space, whereas biological system can integrate all environmental variable over a long period of time in terms of effects which can be easily measured and quantified.

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WHEN TO DO BIO-MONITORING?

Bio monitoring needs to be performed during biologically matured period of a year to get fruitful results. In India due to tropical climate, monsoon occurs for a limited period (average rainy days are 40 in a year), but with high intensity. The entire biological system established during non-monsoon periods is flushes because of floods. After the monsoon recedes, the biological system starts reestablishment. After gradual succession, "mature" ecosystem established. This is the right time for biological sampling.

The sampling time for bio monitoring is preferably selected either in the morning or before the sunset because some of the benefit animals avoid extreme solar intensity and temperature, and seek refuge under the rocks in the interstitial sediments. For the measurement of functional biological parameters, such as photosynthesis and respiration, sampling is performed round the clock.

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WHERE TO DO BIO-MONITORING?

Selecting of the sampling locations and frequency of sampling is a very important aspect for eater quality evaluation. Following criteria may be adopted before bio-monitoring:

- Establish a reference station (s) upstream;
- Locate a station downstream of each discharge point, after complete mixing;
- Determine the linear extent of damage, and establish stations at various distances downstream form the last discharge of concern;
- To Assure correction of biological communities with water quality, characterization of the water of sampling location to be analysed physico-chemically taking a few important parameters; and
- Collect sample from riffle and pool zone of a stream to make a comparison.

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METHODS OF BIO-MONITORING?

Three main types of aquatic bio-monitoring have been recognized, and depending upon the objective, type of bio-monitoring is selected these are;

1. **Toxicity Testing:** For all toxic effluents, standard on toxicity is established by the regulatory authorities and the effluents are monitored for compliance with standard through toxicity test using fish, daphnia or other suitable organisms. Toxicity tests are also performed for setting the standards for various industries as a part of risk assessment.
2. **Early Warning system:** To warm the water supply authorities for sudden change in water quality, and also to the industries for malfunctioning of their treatment plant. This method is used in Western countries.
3. **In-stream biomonitoring.** This is a measurement of change in structural and functional integrity of the aquatic ecosystem in response to pollution.

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CHOICE BIO-MONITORING PARAMETERS?

STRUCTURAL COMPONENTS
The aquatic ecosystem consist several components as shown in Fig.2. Almost all these components are affected directly or indirectly by pollution. For evaluation of water quality only some of these components can be used fruitfully as bio-monitoring parameters. The planktonic organisms in a river system cannot be used as indicator of water quality. They are generally not native of the place of their collection due to their passive movement I flowing waters. CPCB during development and testing of bio-monitoring methodology along with Duch experts has established the fact after a three-year exercise on Yamuna River. The bethic macro-invertebrates were found to be best suitable among all other living systems present in aquatic ecosystem due to the following facts:

- Visible to the unaided eye;
- Stretches having different quality support diverse macro-invetebrate communities;
- Taxonomy is well developed;
- Sampling and observations comparatively easy;
- Provide good experimental possibilities;
- Useful in assessing the impact of municipal, industrial, oily and agricultural wastes; and
- Community response is sensitive to organic loading, substrate alteration and toxic pollution

On the contrary, the only disadvantage is that quantitative sampling is sometimes difficult. Under the Indo-Duch Project, on development of bio-monitoring methodology, several methods for evaluation of bethic macro-invertebrates were tried and the following two methods finally adopted:

Sequential comparison:
The method involves a pair wise comparison of sequentially encountered individuals, and the differences of two specimen which can easily be observed up to the species level whereon taxonomic skill is required. When the next observed animal is different from the last one, a new run starts. The diversity is the ratio of the total number of organisms encountered. The ratio thus obtained (diversity) has a value between about 0 and 1. High diversity of benthic animals always supports a good quality of water.

BMWP (Bio-Monitoring Working Party) Site Score:
This method involves a qualitative inventory of the presence of local macro-invertebrate benthic fauna up to the family level of taxonomic precision. All possible families having saprobic indicator value are classified on a score-scale of 1 to 10 according to their preference for saprobic (oxygen availability)) water quality. The score-class 1 families are mainly occurring in water bodies with a high oxygen demand, whereas the score-class 10 families are restricted to water bodies with low oxygen demand. There are 7 intermediate score classes. The saprobity scores of all families registered are averaged to produce site score.

FUNCTIONAL COMPONENTS
During water quality monitoring of the Yamuna, it was observed that there is a significant change in diurnal concentration of dissolved oxygen is a function of photosynthesis, respiration and diffusion. Odum, the noted ecologist, has developed a method for measurement of photosynthesis and respiration based on diurnal change in dissolved oxygen. He also proposed a system of classification pf waters according to level of saprobity or eutrophication. When evaluated, this system worked very well in the Yamuna river and subsequently in the in the Tungbhadra, the Chaliyar and the Damodar rivers. The findings of all the three approaches were used in the yardstick as explained in the following paragraphs.

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WATER QUALITY YARDSTICK?

Under the Indo-Duch collaboration, a project on development of bio-monitoring methodology for Indian River water quality evaluation was initiated in 1988 the Central Board Pollution Control Board carried out a pilot study on the river Yamuna. With monthly intervals, a number of biological and physico- chemical parameters were determined at 15 stations, which were later reduced to 11 locations along the river Yamuna from Delhi up-steam to Etawah downstream. The main objective for this study was to formulate strategic methods, which can be accepted in scientific and legislative framework for water quality evaluation. The outcome of the study was a generally applicable yardstick for indication of actual water quality, and can be used in water quality management programme in the country.

AMOEBA PRESENTATION
The proposed yardstick consists of an "AMOEBA" (A Method of Ecological; & Biological Assessment) presentation of 8 different indices;

POLLUTIONAL LOAD (STRESS) INDICES

- Bacterial Pollution Index (BPI)
- Nutrient Pollution Index (BPI)
- Organic Pollution Index (OPI)
- Industrial Pollution Index (IPI)
- Pesticides Pollution Index (PPI)

EFFECT (STRAIN) INDICES
- Benthic Saprobity Index (BSI)
- Biological Diversity Index (BDI)
- Production Respiration (PRI)

Each of these indices derived from a set of one or more monitoring parameters and may very according to regional requirements. The detail methods of derivation is presented in a manual, jointly prepared by the CPCB and RIVM, Netherlands.

WATER QUALITY YARDSTICK:
The outcome of all the 8 indices, calculated for the study stretch of river Yamuna in the from of N "AMOEBA' presentation is shown. Levels of each index with respect to their target values at all the 11 locations of the river Yamuna.

FIELD OF APPLICATION IN WATER POLLUCTION CONTROL.:
As mentioned earlier that rational formulation of any pollution control programme of a water body needs to define water quality objectives (target) for that water body in a sound scientific manner. These objectives are used as yardstick to identify the areas, which are in need of restoration; extent of pollution control needed, prioritization of pollution control programmes, and effectiveness of pollution control efforts. The yardstick, which was developed by CPCB, is very much useful for the above purpose.

WATER QUALITY MAP IN GERMANY:
In Germany, bio monitoring is used since almost 30 years from now, for water quality assessment. The whole system is based upon saprobity index, which takes into account the abundancy of the species of macrozoobenthos and their ecological range. This was possible because the species of macrozoobenthos were very well known to the scientist and the correlation between organic load and the occurrence of different species was well established. In other

European countries, like Italy, Spain, France, and United Kingdom, a biotic index based on family or genus level is used. It was calibrated and modified for each region. For system of water quality classes preferably an uneven number is taken. For example, in Germany 4 classes with 3 intermediate classes have been used. To show the results of the investigated water bodies in an easily and understandable way, maps are drawn and each. The maps based on Bio-monitoring show clearly, where the water is polluted and where action for Improvement has to be taken. It is a very useful and powerful tool for decision makers. Map 1 shows the water quality map of the state of North-Rhine-Westphalia, Germany in 1969/1970. The red stretches 9excessively polluted river stretches) are quit high and only some blue, unpolluted stretches are present. The water quality map of the same State after 15 years shows clearly in Map 2 of that the decision makers had taken action. In most of the river stretches, quality had improved which is indicated by a colour change on the river stretches. Attempts are now underway in India at CPCB to utilize the existing taxonomical and chemical data on river Yamuna to evolve a system of classification of river stretches.

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PROBLEMS IN BIO MONITORING OF RIVERS IN INDIA?

- Great annual variation in flow de to heavy monsoon in limited period;
- Unstable river bed causing regular flushing of biotic communities;
- Sudden flashing of rivers;
- In work of agricultural development, the rivers being trapped at several places, and in dry weather not allowed to flow in the downstream. In breaks the continuity of the river and destroy lot of habitats in the downstream of these barrages;
- Sudden flushing of deposited pollutants in the vicinity on major pollution outfall causing a lot of damage to the ecosystem in the downstream;
- Lots of human disturbances, including cattle wading and water-melon farming causing damage to the habitats; and
- Sandy beds being very poor in nutrients and not supporting much benthic animals

To overcome these problems some methods are recommended, such as use of artificial substratum.

ARTIFICIAL SUBSTRATUM
Advanced bio-monitoring technique has been developed at RIZA, Netherlands to observe changes in water quality over the longer term. The tiny molluscs and crustaceans found in and around the river give a good indication of water quality these small animals often attach themselves to stones and gravel along the banks or no the river bed.

The RIZA has been investigating the diversity of these river dwellers for some years using an artificial substrate; baskets containing glass marbles are submerged at a number of places I the river Rhine and Meuse. The baskets are retrieved after four to six weeks and the numbers and species are identified. This method of data collection provides information about the developments in animal life along the rivers. Changes in the numbers or species found are indicative of changes in the water quality in the longer term. This method also makes it possible to assess the immediate consequences of the water quality on the animal life in the river.

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USE FOR TOXICITY MONITORING IN EFFLUENT REGULATION?

Toxicity is the property of a chemical to cause harm to the life prosess.

One of the long-term objectives for pollution Control Boards is that the all the natural water bodies should remain free from harmful effects, to man and aquatic life, caused by polluted discharges. For the regulation of effluent discharges, one should estimate the actual damage an effluent is causing to the aquatic environment. Toxicity test can play a vital role in effective control strategy for complex effluents. Being effective, cheaper and easy to perform, the toxicity test can help decision maker in:

- Identifying environmental problems;
- Establishing priorities for pollution control efforts;
- Identifying and implementing appropriate control measures;
- Monitoring compliance with regularly limit on toxicity

CPCB along with seven other National/State laboratories has formulated a method for toxicity testing of industrial effluents for estimating dimensionless toxicity number within the scope of Water Act, 1974 and EPA, 1986, to be used in the control of compliance with consent procedures.

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EARLY WARNING SYSTEMS ?

In developed countries, like the Netherlands, efforts have been made in recent years to restore animal and plant life, from the sudden deterioration of water quality, along the river Rhine and Meuse. The RIZA has designed and built a computerized alarm system, AQUALARM to warn institutes and authorities involved if the water quality changed suddenly. The RIZA has set up such bioalarm systems at the monitoring stations. :

Bio-alarm with fish
For golden orfe swim in an aqarium filled with river water. Normally, fish swim against the current, six times every hour, river water is pumped through the aquarium at a higher speed for two minutes to check whether the fishes are still displaying their normal swimming behavior. If the river water contains a hazardous substance, the fish try to escape or grow weaker and allow the current to carry them away. In both cases they touch pressure sensitive wires at the back of the aquarium. If this happens several times, the computer are then taken automatically for further chemical place and, if so, which substance is involved. The fishes given fresh water immediately after the alarm has been raised and a new batch of fish is put to work every week.

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BIO-AVAILABILITY

It has been well established since last ten years that hydrophobic organic chemicals, and also inorganic contaminants, that enter the aquatic environment, rapidly becomes associated with sediments and suspended particles. The sedimentation of the latter form one of the most important 'Sink' of pollutants from the column these ailability of these mainly sediment sorbed chemicals to the biota is important as the sediment reservoir may constitute a primary source of contamination for benthic organisms. Even when the quality of the overlaying water is again improving, the polluted sediments still act as a long-term threat to organisms exposed to it. However, the main rout of exposure to sediment inhabiting species is the one via the (pore) water phase. The biological community strongly influences the Physical & Chemical environment in the sediment and this influences the bio-availability of contaminants by several abiotic and biotic factors such as:

- Primary productivity influences Ph conditions which in turn influences metal chemistry; and
- Sulphate reduction to sulphide by bacteria facilities metal sulphide formation etc.

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MONITORING OF BIO-ACCUMULATION & BIO-MAGNIFICATION

Bioaccumulation is the ability of a living organism to concentrate, accumulate, the magnify a chemical substance either directly from a surrounding medium or indirectly through food chain. Benthic macro-invertebrates which are living at sediment-water interface are directly exposed to sediment-bound metals and are capable of accumulating metals from interstitial water and from ingested sediments. Such organism is often refereed to as bio-accumulative indicator, which accumulates metals in a way so as to reflect environmental levels of those substances of the extent to which the organism has been exposed to them. Concentration levels of heavy metals accumulated in aquatic organisms can be of several orders of magnitude higher then those in ambient water. As a consequence of bioaccumulation, short-term external, exposure can result long-term internal exposure of aquatic organisms. Because of it, not only man is at risk, but plants and animals, occupying the higher tropic levels in aquatic ecosystem, are also in danger of being affected by bioaccumulations. This is demonstrated best by the benthic fauna of river Yamuna at two stations, namely Palla, a relatively clean stretch, and Palwal the eutrophic stretch of Yamuna. The heavy metal accumulation study was carried out for two-year samples, 1991-92. An average of concentrations was calculated for both the stations. This was compared with the average heavy metal concentration in water and sediments. The indicates that the levels of heavy metal concentration in water at both the stations. Palla and Palwal, in river water were exceeding the environmentally safe concentration as shown in Table 2.

Name of Heavy Metal	Safe Concentration In Water (mg/1)	Safe Concentration in Sediments (mg/kg dry weight
Cadmium	0,00016	14.0
Zinc	0.0016	120.0
Nickel	0.0014	7.4
Lead	0.002	860.0
Chromium	0.002	270.0
Copper	0.007	6.0

On the other hand, the levels metals in the sediments of at both the stations are far below the safe concentration level except Nickel and Zinc. It is also clear from the results that although the sediments are not e\very toxic to the benthic animals, the bioavaibility for t\heavy metals to accumulate in the biota is more form the water phase than the sediments. The through 10 indicate a comparison of heavy metal bioaccumulation at the two stations which are located at Yamuna upstream and down stream of Delhi, i.e. Palla and Plawal respectively. The increased levels of bioaccumulation of Palwal is mainly due to the input of domestic and industrial wastewater joining the river Yamuna from Delhi and from Ghaziabad through the river Hindon.

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MENTUM EFORMITIES IN CHIRONOMUS LARVAE

Most studies on alternations of benthic macro-in-vertebrate community structure are related to trophic (nutrient) and general pollution conditions rather than to exposure to specific persistent toxic substances. More recently, sublenthal effects in relatively tolerant-worms like Chironomid deformities in mandibles or antennae, and Oligochaete abnormalities apparently have an indicative value ot distinguish chemically polluted sediment areas. One of such approaches is available to measure morphological responses in aquatic communities to environmental perturbations including sediment contamination i.e. mentum deformity in chironmous larva.

Mentum deformity is the morphological changes in the teeth arrangement tin mouthparts of chironomid larvae due to toxic sediments. Shows the structure of normal menthm.

The family of chironomid is ubiquitous and represents the largest family of aquatic insects. These species are tolerant to the organic pollution and found in high densities in sedimentation areas where accumulation of toxic pollutants can be expected. Most contaminants in the water phase adsorb to fine organic or inorganic particles. Due to sedimentation of these particles contaminants accumulate in the sediments. Benthic chironomid from a primary link in the transmission of contaminants from sediments to the higher level of the food chain. The larval stage of chironomid are exposed to contaminant throughout the longest, most critical and metabolically active stage of their life cycle.

The study on mentum deformity of chironomus was carried out at several sites along the Yamuna River, the Agra canal, the Hindon and in some drains in the Union Territory of Delhi. The highest percentage of mentum deformities was found at downstream of Okhla Barrage (11.4%), and the lowest at downstream of Wazirabad barrage (1%) show the levels of abnormality in the mentum of chironomid at the various locations in the Yamuna.

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CPCB PUBLICATION DURING SEPTEMBER, 1994- AUGUST, 1995*

- Water quality Atlas of India
- Chlor-All\kali industry (Hindi version)
- Comprehensive Industry Document on Lime Kiln Industry
- Pesticides Industry: Status
- Comprehensive Industry Document on Edible Oil & Vanaspati Industry
- Report of the Expert Group on Utilization of Fly Ash in Cement Industry
- Basin & Sub-basin Inventory of Water Pollution- Narmada Basin
- Basin & Sub-basin Inventory of Water Pollution- Tapti Basin
- Wastewater Management in Pesticides Industry
- Comprehensive Industry Document on Starch and Glucose (Maize Processing) Industry
- Pollution Control Acts, Rules & Notifications Issue There under (Third Edition)
- Comprehensive Industry Document on Fertilizer Industry
- Basin Sub-basin Inventory of Water Pollution- Cauvery basin Report
- Comparative Evaluation of Treatment Technology for Cement Industry
- Inventory of Large & Medium Water Polluting Industries Vol-II (Gujrat)
- Environmental Audit NOCIL-Agrochemicals
- Retting of Jute Fiber- its Impact on Environmental
- Environmental Auditing in Polluting Industries
- Identification of Hazardous Waste Generating Industry in the State of M.P. UP. Rajasthan, Punjab, Haryana & H.P.
- Management of Municipal Solid Wastes- Status and Option
- Classification of Industries for Consent management
- Comprehensive industry Document on Dairy Industry
- Technologies for Control of NOX emissions
- Guidelines for Establishment, Evaluation and Gradation of Environmental Laboratories
- Water Quality Statistics of India- 1992
- Paryavaran Pradushan Vaigyanik Evam takniki lekhon ka sankalan (1992 evam 1993)
- Implementation Status of the e Pollution Control Programme in Major Polluting Industries
- Industry - specific Pollution Control Status in Problem Area, Vol. -1 (Korba, Chamber, Angul, Talcher and Vishakhapatnam)
- Cost Benefit Analysis of Dust Control Equipment in Cement Industry
- Action Point for pollution Control in Problem Areas

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FORTHCOMING EVENT

DUREM-1

FIRST NATIONAL WORKSHOP ON DEVELOPMENT AND USE OF ENVIRONMENTAL REFERENCE MATERIALS

FEBRUARY 14-16, 1996

Topic to be covered

- Analytical quality Control Environmental Measurements
- CRMs and their role in Environmental Measurements
- Methods/ Procedures for Development of CRMs for Environmental Measurements
- Traceability and its Realization
- World Sources of the availability of CRMs
- Exixting needs of Environmental CRMs in India, and plans for their development

For details please write to:

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READER'S COLUMN

" I appreciate the efforts of COCB for compilation and collection of very useful information on Air Pollution and its Control. This is very useful, informative and educative issue of the series and one can use as reference for the purpose of various information pertaining to source, control and effect of air pollution including public participation for control of air pollution"

Dr. A.K.Singh, Secretary, Sonepat Management Association, Sonepat.

"I have gone through it (PARIVESH, March, 1995 issue), and become marginally more knowledgeable about our problems for water pollution."

Mala Dayal, Chief Editor, National Center for Children's Literature, New Delhi

"We have gone through your Newsletter (Agro-based industry issue) and find it contains lot of useful and interesting Information."

Mr. G.K. Dave, Resident Manager, Reva Enviro System (P) Ltd. Nagpur

" I received Parivesh; Vol. No.3 (Agro-based Industries issue) and delighted to find that the same is exceptionally useful for studying the environmental aspects related on Agro-based industries like Jute industry, where I am engaged."

Dr. N.C. Som, Head, C.P. Division, Indian Jute Industries Research Association, Calcutta.

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PUBLIC NOTICE

In pursuance of the notification issued by the Ministry of Environment & Forests, Government of India on March 13,1992 [amended vide notification no. GSR 386 (E) dated April 22,1993] under the Environment (Protection) Rules, 2986 al those carrying on an industry, operation or process requiring consent to operate under Section 25 of the Water (Prevention & Control Pollution) Act, 1974 (6 of 1974) and/or under Section 21 of the Air (Prevention & Control of Pollution) Act, 1981 (14 of 1981 and/or authorization under the Hazardous Waste (Management & Handling) Rules, 1989 issued under the Environment (Protection) Act 1986 (29 of 1986), are required to submit the Environmental Statement in prescribed form to the concerned State Pollution Control Boards/ Pollution Control Committees in the Union Territories.

For the current financial year (1994-95), the Environmental Statement is to be submitted on or before 30 September, 1995. Non-compliance with this mandatory requirement amounts to violation of the Environment (Protection) Act, 1986.

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Ministry of Environment & Forests, Govt. of India

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	Agro - based Industries - December 1994