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CONSIDERATIONS IN SETTING INDUSTRIAL EFFLUENT STANDARDS

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SYNOPSIS

The various considerations which will have to be taken into account in setting effluent standards for industrial wastewater discharges are detailed and discussed. The major considerations are characteristics of the recipient system, characteristics of the wastewater, technological character of the industry, economics of treatment and variability in the performance of wastewater treatment systems. A model for evolving effluent standards based on the considerations of characteristics of recipient system and economics of treatment where the recipient system is a water body is presented. The model envisages a minimum level of treatment irrespective of the quality requirements of the recipient water body. The quality requirements are dictated by the best use of the particular stretch of the recipient water body. The model is based on the mixed approach of stream standards and uniform effluent standards.

SUB TOPIC B3

S O M M A I R E

Nous avons énuméré et discuté les divers aspects qu'il faudrait prendre en considération afin de fixer les titres de l'effluent pour déterminer la qualité du débit des eaux usées industrielles. Les lignes de force principales sont, à savoir : les particularités du système récepteur et celles des eaux usées; le caractère technologique de l'industrie, les aspects financiers de traitement et la variabilité dans la performance des système de traitement des eaux usées. Nous avons également proposé un modèle dans le but de développer des titres d'effluent fondés sur, au cas où une rivière fonctionne en tant que système recepteur, des considérations relatives aux particularités du système. Le modèle envisage un niveau minimal de traitement sans tenir compte des besoins en qualité de la rivière réceptrice.Ces besoins en qualité sont prescrits par la meilleure exploitation possible de l'étendue particulière de la rivière réceptrice. Ce modèle découle d'une approche mixte des qualités des fleuves et des titres uniformes de l'effluent.

E L R E S U M E

Se trata en detalle de las varias consideraciones que se debe tener en cuenta en formular las normas de effluente para las descargas del desagüe industrial. Las principales consideraciones son las características de desagüe, carácter tecnológico de la industrial, las economías de tratamiento y la variabilidad en el funcionamiento del sistema del tratamiento de desagüe. Se presenta un modelo para evolver las normas de effluente basadas en las consideraciones de las características del sistema recipiente y las economías del tratamiento dado el sistema recipiente es un rio. El modelo preve un nivel mínimo de tratamiento sin consideración a los requerimientos de las calidad son gobernadas por el major uso de la parte particular del rio recipiente. Se basa el modelo en el enfoque mixto de las normas de corriente y las normas uniformes de effluente.

1. INTRODUCTION

The past two decades have witnessed the deep concern of all countries over the pollution of water resources. The concern has, worldover, manifested itself in legislation on water pollution control. The legislations differ in their scope and contents (Ozolins et. al. 1977). However, the objectives by and large are the same. Generally the administrative and legal mechanisms are covered in the statutes leaving the technical aspects to be dealt with the regulations issued under the main statute or to be decided upon by the administrative body. The statutes provide for a consent system to control water pollution that might result from discharges emanating from industries or human settlements or may be also from any other human activity. The consent is not a permit to pollute but an instrument to cut down the discharge of pollutants. The question immediately following is "cut down to what level". This level, in terms of concentration or mass per unit of productionor mass per unit time, is termed as the discharge standards. The considerations that should precede the setting of the standards for discharges are discussed in this paper. The considerations are many and for some of them a strong data base is a prerequisite. Such a data base may not exist in the developing countries but then the lack of it should not preclude seting the effluent standards based on other considerations and enforcing the standards through the consent system. The implication is that the standards may have to be changed if so required by the considerations for which data have become since available. The reaction of the industries to such a shifting standards may be unfavourable but then it may not be advisable even temporarily to halt pollution control till complete data are collected to enable framing of standards based on all the considerations.

2. CONSIDERATIONS IN SETTING STANDARDS

2.1 Characteristics of the recipient system

The primary consideration in framing the standards is the nature of the recipient system. The industrial effluent may be disposed of into municipal sewer or combined industrial wastewater sewer, inland surface sweet waters, estuaries, coastal waters or lakes or on land. It is not only the above different types of recipient systems that have bearing on the stipulation of standards but also in some cases. The characteristics of the particular system, such as inland surface sweet waters.

2.1.1 Municipal Sewers

Treatment of industrial wastewaters with the domestic wastewater has the following inherent advantages: due to economy ofscale national cost on pollution control is reduced; treatability of the industrial wastewater is enhanced; the problem of non availability of space for constructing treatment units in industries located in cities is solved; the difficulties experienced by small industries on account of various reasons to install and successfully operate wastewater treatment plants are sorted out. However the industrial wastewaters cannot be accepted indiscriminately into the municipal sewers. The sewers have to be protected as well as the men who may have to work in the sewers. The biological treatment process provided to the combined wastewater must also have to be protected. In Table 1 is presented the concentration of heavy metals that would affect aerobic treatment process (Jones, et, al, 1970).

TABLE 1
THRESHOLD TOXIC LEVEL OF HEAVY METALS TO AEROBIC TREATMENT PROCESS

Metal	Concentrationin mg/l
Chromium (IV)	10
Copper	1
Nickel	1.25
Zinc	5-10

Therefore limits on heavy metals will have to be imposed on the discharges from the industries into the sewers in order to protect the biological treatment process. Similarly limits on pH and Sulphate willhave to be incorporated to protect the material of the sewer. The limits on Biocnemical Oxygen Demand (BOD) and suspended solids are governed by the treatment capacity available at the terminal point and how much of it the municipality can allocate to industrial load.

It is seen from the above that the industries if need be may have to provide some preliminary treatment. In the developing countries, if India is a typical example, to the well established human settlements are the industries especially the small and the medium attracted. Perhaps the solution to water pollution control in such situations lies only in the collection and treatment of domestic and industrial wastewater through a combined system. The industries will have to comply with the standards as applicable to the sewer as the recipient system. In Table 2 is presented suggested standards for discharge into sewers. The suggested limits for BOD and suspended solids can be varied by the authority owing the sewer and the terminal treatment facility. Another common situation that may be obtained is the Industrial Estates where a large number of small and medium industries, at times as many as 400 in number, are located in an area of a few hundred hectares. Owing to the size of the individual industries, from the points of view of overall pollution control cost, operation and performance of treatment units and the objective of improving the quality of receiving water body the best solution will be to provide combined collection system and a terminal treatment facility. The individual industrial unit would have to treat its effluent only to the extent of protecting the sewers and the terminal treatment. If the combined wastewater after treatment is utilized for irrigation purposes special parameters such as Boron, total dissolved solids and chloride may have to be included in the list of parameters furnished in Table 2. However stipulation of these parameters to a relevent industrial unit will depend on relative flows.

TABLE 2
TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENT DISCHARGED INTO SEWERS

Serial Number	Characteristics	Limits
1	pH	5.5-9
2	Temperature, °C	45
3	Suspended solids mg/l	600
4	Biochemical oxygen Demand for 5 days at 20°C, mg/l	500
5	Oil and Grease, mg/l	100
6	Phenolic compounds (as C_6H_5OH), mg/l	5.0
7	Ammonia coal Nitrogen (as N), mg/l	50
8	Cyanides (as N), mg/l	2.0
9	Sulphates (as S04), mg/l	1000
10	Chromium (hexavalent) (as cr),	2.0
11	Copper (as cu), mg/l mg/l	3.0
12	Lead (as Pb), mg/l	1.0
13	Nickel (as Nc), mg/l	2.0
14	Zinc (as Zn), mg/l	15

SOURCE: Indian Standards Institution IS:3306-1974

2.1.2 Rivers

The rivers transport materials in dissolved and suspended forms to the ultimate sink, seas. The transport imparts certain quality characteristics to the water depending upon the nature of the materials. Such quality acquisition may result from natural causes or human interference. These acquired quality characteristics may render the water unfit for a particular use. It is not necessary and may be not possible to keep riverine systems in pristine quality or even at an uniform quality throughout its length. However it is necessary that the various stretches of a river are maintained at the characteristic quality level which will sustain the respective best use of the stretches. It implies then that water quality criteria for all uses have to be evolved. In the development of criteria the target for protection has to be identified. The targets could be human health and aquatic fauna and flora. The inter relationship of the targets is realised bu the extent to which it should affect the immediate water quality objectives of a country is governed by the compulsions and priorities in the goals of the society and so also is the extent to which protection has to be given. Once the best use of the various stretches of the river are determined based on present and future uses, the water quality at which each of the stretch are to be maintained, stemming from the respective water quality criteria, to sustain the uses are known. The effluent standards to be set for an industry or a group of industries discharging into any of the stretch is governed by the required water quality of that stretch. The allocated pollutional load for a stretch may be equitably distributed among the polluting sources so that the total cost of pollution control remains optimal. It should not be given construed, however, that industries could be given the advantage of dilution to the extent that they do not need to provide any pollution control device. Because under the pretext of presently available dilution, industries discharging into that stretch of river may get a blanket clearance for using the stretch as a sewer and would be reluctant to install pollution control devices when situation in future demands so. At this point it should be noted that a sound water quality management programme should take cognizance of dilution and dispersion available with the recipient water body, providing, of course, that certain basic minimal pollution control devices are installed by the industries. Toxic, biomagnifiable and bioaccumulative chemicals are to be considered under a different footing.

In the preceding paragraph evolution of effluent standards based on water quality criteria of the receiving water is explained. This is a logical blending of the two methods developed to control pollution of water at the sources. In one of the method effluent standards are specified which are evolved regardless of location and type of industry but some specify standards industry specific but regardless of location. In the other method the water quality standards of the receiving water are only specified leaving the industry to control the quality of its discharge so that the water quality standards are maintained. The latter method is abandoned by most of the countries because of difficulty in the administration of the system. In locations where more than one industry are discharging their effluents in the event of failure to maintain receiving water standard it is difficult to identify the violator. The method of uniform effluent standards, regardless of type of industry and location, although easy to administer suffers from many limitations. The limitations are that the method is inequitable from both the view points of dischargers and maintenance of receiving water standards, that the method becomes insensitive to the quantum of pollutant cast in the receiving water if effluent standards are spelt out only in terms of concentration, that the method gives hardship to industries whose wastewaters are difficult to treat and that the method in few cases may induce the industry to dilute its wastewater in order to conform to the effluent standards thus jeopardizing the very concept of water resources conservation. In order to overcome the limitations of the two methods the logical step is to evolve effluent standards related to water quality requirement of the receiving water. The model presented in the later section attempts to lay out the procedure for evolving such an effluent standard.

The variation in the flow of a river should reflect in the effluent standards if optimum utilization of the resources is our prime objective. It is safer to evolve the effluent standards to maintain the required water quality of the river at its minimum flow. But it would be ideal if seasonal effluent standards could be set especially in respect of rivers whose flow variation is considerable. There are some inherent difficulties in doing this but attempts may be made to use the very large dilution available at times, as in the case of monsoon fed rivers, in respect of certain pollutants such as oxygen consuming substances.

2.1.3 Estuaries and Coastal waters

The rivers being unidirectional in flow, the rate of flow is the only hydrolic parameter of concern. In the case of estuaries dispersion of pollutants is of importance. In the scheme for setting effluent standards that is presented later in the paper the water quality at which the estuarine portion of the river is to be maintained is considered and that water quality is dependent upon the criteria of the identified best use of the estuary. Predictive capacity to estimate the permissible additional pollutional load into the estuarine and river systems and to estimate the water quality consequent to a discharge should form part of the water quality management programme. The biological sensitivity of the estuaries will be reflected in the development of water quality requirement. The two important criteria for coastal waters are coliform organisms and floatables. The effluent standard to be set for a discharge into the coastal waters may be based on the required water quality in the beach where bathing or other activities take place. The place and manner of disposal are of considerable importance in the case of marine discharges. They may be considered as equally important components of the consent or permit system as the effluent quality standards is in other cases. In Table 3 are presented water quality criteria for coastal waters for different beneficial uses.

2.1.4 Land

Perhaps the best recipient system for industrial wastewaters is the land. By land application is meant the utilization of wastewater for agricultural purposes. The soil mantle has considerable capacity to adsorb various components of industrial wastewaters and moreover the ground water gets recharged. Direct pollution of surface waters is prevented.

Table 3

WATER QUALITY CERITERIA FOR MARINE WATERS
(Source : Indian Standards Institution IS:7967-1976)

Sl. No.	Characertistic	Criteria for: Bathing, Recreation, Shell Fish and Commercial Fish Culture and Salt Manufacture	Criteria for: Harbour Water
1	2	3	4
1)	Colour and Odour	No noticeable colour or offesnive odour	No noticeable colour or offensive odour
2)	Floating material	No visible floating matter of sewage or industrial waste origin	No visible floating matter
3)	Suspended Solids	No visible suspended solids of sewage or industrial waste origin	-
4)	pH value	6.5 to 8.5	6.5 to 9.0
5)	Free ammonia(as N), mg/1, Max.	1.2	-
6)	Phenolic compounds (as C_6H_5OH), mg/1 Max.	0.1	-
7)	Dissolved oxygen, Min.	40 percent saturation value or 3 mg/1 whichever is higher	3 mg/1
8)	Pesticides(chlorinated hydrocarbons) (as Cl),mg/1, Max.	0.002	-
9)	Arsenic (as As), mg/1, Max.	0.2	-
10)	Mercury (as Hg), mg/1, Max.	0.0003	-
11)	Oil & grease substances(sampled in 30 cm surface layer)mg/1, Max.	0.1	10
12)	Biochemical Oxygen demand(5 days at 20°C),mg/1, Max.	5	5
13)	Confirm bacteria, MPN index per 100 ml, Max.	1000	2500
14)	Bio-assay test	Not less than 90 per cent of test animals shall survive in 96 hr.test	-

Source: Indian Standards Institution IS:7967-1976

However required area of land is not always available. The main considerations in setting effluent standards for discharge on land are the concentration of total dissolved solids, chlorides, sulphates, boron and percent sodium.

2.2 Characteristics of wastewater

The second consideration in setting effluent standards is the characteristics of the wastewater.

2.2.1 Composition of wastewater

The choice of pollution parameters on which limits will be stipulated in the effluent standard for an industrial discharge, naturally, will depend on the composition of the wastewater. The industrial wastewaters may contain oxygen consuming organic substances, heavy metals, toxic chemicals, mineral oils and others. The substances may also be grouped as biodegradable, nonbiodegradable, bioaccumulative and biomagnifiable. The consideration in etting limits in respect of biodegradable matter would be the demand on the oxygen resources of the receiving water body. The requirement of 4 to 5 mg/l of minimum dissolved oxygen in the ambient water to protect fish life is well documented. The criteria for fresh water uses include the parameters of BOD and dissolved oxygen since they speak of the pollutional state with respect to biodegradable matter. Limits on the parameter of chemical oxygen Demand (COD) are laid down to regulate discharge of organics not measured by BOD. Some of the substances contributing to COD which cannot be biologically degraded in the aquatic environment may have effects, individually or in combination, on human health or on aquatic fauna. In case the effluent is suspected to be toxic tolerance limit in terms of survival of fifty percent of a specified test organism over a specified period of time may be stipulated.

In the case of substances such as pesticides and mercury the standards may have to be based on their bioaccumulative/biomagnifiable characteristics.

2.2.2 Other factors

The following factors resulting from the composition of the wastewater have bearing on the standards and they are grouped together since they are interdependent.

- treatability of the wastewater
- technological availability for treatment
- cost of treatment

Before setting a limit on any of the constituents it is necessary for the regulatory agency to consider whether the limit could be achieved in practice within reasonable cost. Standards may be set solely based on availability of practicable technology without considering the factors of cost and the capacity to take up pollution by the recipient system. However, as mentioned earlier setting standards is conditioned by what the society wants and can afford. By%

the same token it is also the responsibility of the regulatory agencies to set objectives and accordingly design the pollution control efforts taking into account the overall needs of the society. The cost of treatment is not directly proportional to the levels of treatment and at high levels become very high. Certain wastewaters cannot be treated within reasonable cost to levels which could be achieved easily for other wastewaters. An example would be the spentwash from molasses distilleries. The concentration of the biodegradable organics is high at about 40,000 to 50,000 mg/l in terms of BOD, rendering it economically not possible to reduce it to normal standards of 30 mg/l or so. The availability of technology in the country is also to be considered. The cost of pollution control is after all borne by the society. The effluent standards are to be set so that the expenditure on this front is consistent with the benefits derived by the society. The model for evolving effluent standards for discharge into water bodies presented in Section 3 attempts to take into consideration the factors discussed thus far viz;

- the water quality requirement of receiving water
- the treatability and cost of treatment of wastewater
- economic viability of the treatment

2.3 Technological character of the industry

The technological character of the industry should be taken into account while setting the effluent standards to it. There is bound to be conflict while considering so many factors but some compromise will have to be arrived at. The built-in systems for recovery and reuse of chemicals, nature of catalysts used, nature of raw materials used are some of the factors which characterise the technological age of an industry. The quantum of pollutants discharged from an industry is dependent on the technological age. Generally older technologies result in higher discharge of pollutants. Since the cost of treatment is not directly proportional to levels of treatment, industries based on older technology would find it comparatively too costly to achieve the same standard as the industries based on newer technology.

An example in respect of how raw materials used could affect the standards, from Indian experience, would be laying down standards for mercury loss in caustic soda plants. The common salt available to the industries contains considerable impurities. The salt has to be purified and considerable mercury is lost with the brine mud. Therefore setting a stadnard in this case comparable to situations where pure brine is available may not be right.

2.4 Variability in performance of wastewater treatment systems

The performance of physico-chemical and especially biological treatment units are subject to variation. Therefore in setting effluent standards variability in performance should be taken into account. As an example the effluent limitations developed for organic pesticide chemicals manufacturing industries in the United States of America is presented in Table 4.

Table 4
EFFLUENT LIMITATIONS FOR ORGANIC PESTICIDE MANUFACTURING INDUSTRIES

Effluent characteristics	Effluent limitations Average of daily values for 30 consecutive days
BOD (5 days)	1.6 kg/ K Kg
Chemical Oxygen Demand	9.0 "
Total Suspended Solids	1.8 "
Pesticide Chemicals	0.0018 "
pH	6 to 8

SOURCE: Effluent limitation guide lines for the Pesticides chemicals manufacturing point source category - PB 285 480 April 1978, U S Environmental Protection Agency Development Document

2.5 Expression of effluent standards

The effluent standards may be expressed in the following ways

- concentration
- mass per unit time
- mass per unit of product

The shift in emphasis from a mere concentration standard to that of quantum of pollutant is reflected in the modification of units of expression. The units of expression also indirectly indicate how the compliance will be ensured. The mass per unit time or mass per unit of product will not be based on single grab sample and thus variations in the performance of the treatment plant is taken care of.

3 A Model for Evolving Effluent Standards

3.1 The concept of evolving effluent standards based on the following factors was discussed elsewhere:

- the water quality requirement of receiving water
- the treatability and cost of treatment
- the economic viability of treatment

The model illustrated in Figure 1 is designed to evolve industry specific and location specific effluent standard (CHAUDHURI AND RANGANATHAN, 1980). At national level it is possible to evolve industry specific effluent standards and not beyond that. The industry specific effluent standards are to be examined at the local level by the concerned authority giving due regard to the water quality requirement of the receiving water into which the discharge is planned to be made. Such an examination would result in the modifications of the industry specific standards into location specific also. The industry specific effluent standards which will be evolved at the national level is termed as Minimal National Standards (MINAS). The model envisages a minimum treatment to the wastewaters consistent with the annual burden of expenditure a particular industry can bear. The annual burden is reckoned as percentage of annual turnover of the industry. Before the percentage is arrived at dialogues are held with the industrial units belonging to the industrial group under consideration based on the comprehensive document prepared on the industry. The comprehensive document is a status report on the industry in the country and would deal with, among other aspects, wastewater treatment providing the following details:

- identification of different units process specific for the wastewater
- identification of different treatment schemes comprising individual unit processes
- estimating capital and operation & maintenance cost expressed as annual burdens for each of those schemes in respect of typical capacity of production
- estimating the quality of treated effluent corresponding to each of the schemes
- expressing each of the annual burdens as percentage of annual turnover of the industrial unit

At the dialogues the critical percentage of annual turn over is finalised. The treatment scheme corresponding to the critical percentage being known, the effluent quality achievable by the treatment scheme is the MINAS. In the case of certain industries even the best stage of treatment would not result in an annual burden which is higher than the critical percentage or it may be just equal. Such industries are termed as soft industries. There may be medium hard industry for whom the annual burden of the minimal stage of treatment is above the critical percentage.

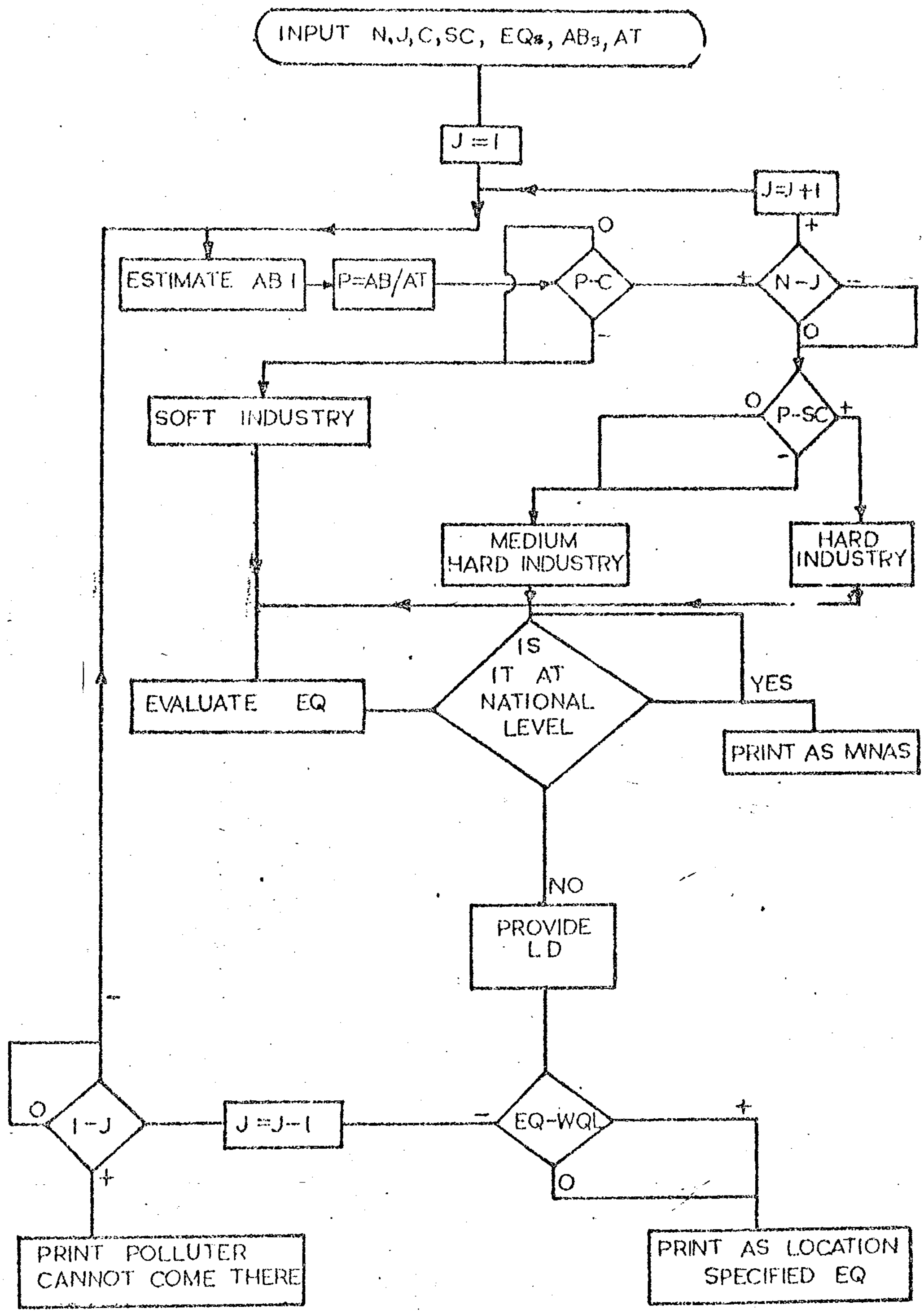

FIGURE 1: MODEL FOR EVOLVING INDUSTRY AND LOCATION SPECIFIC EFFLUENT QUALITY

Explanation for notations used in Figure 1

N	=	Total number of pollution control stages, the annual burden of each stage of treatment is required to be evaluated.
J	=	Stage of pollution control under consideration; when J = 1, it indicates the best stage of treatment which obviously uses the best available technology of treatment
C	=	Critical percentage of Annual Turnover of the Industry.
SC	=	Super-critical percentage of Annual Turnover of the industry
EQ	=	Quality of treated effluent corresponding to any stage of treatment.
AB	=	Annual Burden of any stage of treatment
AT	=	Annual Turnover of the Industry
P	=	AB/AT, expressed as percentage
LD	=	Location Details of disposal of treated effluent; inland surface water, estuaries, coastal waters
WQL	=	Water Quality requirement for the location

of annual turnover but below the super critical percentage. The super critical percentage is also finalised at the dialogues with the industry. The industries for whom the annual burden of for minimal stage of treatment remains above super critical percentage of annual turnover are hard industries.

The determination of location specific effluent quality requires the input of details of the location of disposal. In the previous sections reference was made to best use and water quality criteria for different uses of recipient water bodies. From the above two considerations the permissible quality of effluent from the industry is determined. When the quality achievable by a particular stage of treatment matches the permissible effluent quality then it becomes the effluent standard for the industry. In certain cases even the highest stage of treatment may not match the permissible quality in which case the industry, if it is a proposed one, cannot be located at the location.

3.2 Classification of Waters

It is seen that in order to evolve the permissible effluent quality in a particular situation the primary requirement is to determine the best use of the recipient system and the water quality required to sustain that use. The following uses are identified for fresh and sea waters.

Fresh Waters

- Drinking water source without conventional treatment but after disinfection
- Outdoor bathing (organised)
- Drinking water source with conventional treatment followed by disinfection
- Propagation of wild life
- Fisheries
- Irrigation
- Industrial cooling
- Controlled waste disposal

Sea Waters (including estuaries and coastal waters)

- Salt pans
- Shell fishing
- Contact water sport

- Commercial fishing
- Recreation (non-contact)
- Industrial cooling
- Harbour
- Navigation
- Controlled waste disposal

The listing of the uses is in the order of the degree of water quality requirement. It is obvious that any stretch of flowing (lotic) water body will be subjected to more than one of the above listed uses. The scheme of classification, to deal with such multiple use situation, is evolved based on that use which demands the highest degree of water quality. The use identified is referred to as the designated best use . The designated best uses are grouped into a class system as indicated below:

Fresh Waters

Designated best use	Nomenclature (class of water)
Drinking water source without conventional treatment but after disinfection	A
Outdoor bathing(organised	B
Drinking water source with conventional treatment fällowed by disinfection	C
Propagation of wild life, fisheries	D
Irrigation, industrial cooling and controlled waste disposal	E

Sea Waters (including estuaries and coastal waters)

Salt pans, shell fishing, contact water apart	SWI
Commercial fishing, recreation(non-contact)	SWII
Industrial cooling	SWIII
Harbour	SW IV
Navigation ,controlled waste disposal	SW V

The various zoned stretches of water bodies of the cuntry are classified as per the scheme after identifying the uses and determinigg the designated best use of the stretches. With the knowledge of the water quality criteria for the various uses, criteria for each of the class is developed. It is this water quality of the recipient system that has to be taken into account in determining the location specific effluent standard for an industry. While developing the water quality requirement for each class it may not be necessary to include all the parameters relevent to a use.

4 CONCLUSIONS

The various considerations that will have to be taken into account while setting effluent standards are presented. An approach based on recipient system requirement and cost of treatment is presented.

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