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PLANNING EFFECTIVE INDUSTRIAL LIQUID WASTE CONTROLS IN DEVELOPING NATIONS

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Abstract. The environmental planning principles described in this study address a problem which many developing nations face at some point along their industrialization process; alarming levels of water pollution, and limited background, expertize and organization to combat it effectively.

A rapid pollution assessment methodology has been recently developed [1], [2], [3] enabling such countries to conduct valuable waste source inventories within reasonable time, with few people and little support. The present study describes how to use such inventory data in order to derive high priority waste control measures, formulate an effective national strategy for industrial waste control, organize meaningful industrial effluent survey and water monitoring programs, as well as lay down a rational land-use planning policy for industrial expansion.

1. Introduction

A pollution abatement strategy focussing only on liquid waste controls without simultaneous consideration of the air emissions and solid waste problems is generally inadequate since, on one hand it does not ensure the economic viability of the individual plant, while on the other does not ensure the most rational allocation of the often limited resources on a national level.

Based on the above, our present study, which deals only with liquid wastes, should be viewed as the first stage of an integrated environmental planning exercise providing the necessary input into the latter.

Developing nations, in their initial pollution abatement efforts, concentrate on the enactment of pollution control legislation, hoping, often unjustified, that this is the basis of the pollution control problem. Initially, in the typical case, quality standards are set for the receiving waters based on the desirable water usage. It is however impractical to try to justify effluent treatment requirements on individual source based on such standards. The next step is usually the adoption of effluent standards, which in the best case are copies of those in industrialized countries. Such standards however do not reflect the character of the local problem, they are usually much too strict, while the organization which would be required for their implementation is often nonexistent.

Nontheless, to the extent that pressure is put into industry to implement controls, money is spent. The results are, however, most often disappointing, and an overall negative attitude is often encountered:

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(a) Industry finds that it is impractical to try to meet the imposed standards, becomes less cooperative, builds poorly designed waste treatment facilities and does not operate them properly.

(b) Politicians get the impression that normal waste control measures yield poor results and radical measures, such as relocation of industries or limitation of the industrial growth, may be the only solution for areas with pollution problems.

(c) Public opinion relates industrial growth to degradation of environment. Thus, assessment of the economic benefits of industrialization versus the degradation of environment, leads to a strong public opposition to further development.

Based on the above, it could be seen that the key to successful pollution control is the development of a truly effective strategy within the existing economic, technical and organizational constraints. Once a pragmatic strategy has been developed, it is usually possible to start implementing it using available laws. New pollution legislation should be preferably enacted only after both the objectives and the strategy have been clearly defined, for it should express precisely the spirit of the overall pollution abatement philosophy.

2. Peculiarities in Developing Nations

Environmental planning problems in developing nations present notable differences compared to the situation in industrialized nations.

In many cases the typical size of industrial operations is considerably smaller compared to that in industrialized nations. This magnifies significantly the economic impact of the waste treatment requirements, since the treatment cost per unit volume of waste (or per unit of product) increases as the size of the plant gets smaller.

Waste treatment installations to function properly require skilled operators, which are not always available in developing nations. Thus, it is often beneficial to use simpler waste treatment technology than that employed in the developed nations. In order to stress the importance of simple technology, it should be mentioned that even in the United States, a 1977 study [4] showed that about 50% of the biological domestic waste treatment installations were not functioning properly, and the main cause for this was attributed to lack of operator training.

Furthermore, a great portion of the technology and equipment is normally imported, straining the foreign exchange position of many developing countries. Utilization of simple technology reduces such foreign dependence allowing greater contribution of local designers and contractors.

Successful implementation of any waste control strategy requires an adequate level of organization, experience and background work from the responsible pollution control authorities. Inefficiencies here, which often exist, should be seriously considered in the formulation of any effective strategy.

From the above it could be seen that fundamental differences between developing and developed countries hamper the successful straightforward transplantation of methodologies, design practices, legislation and standards from the latter to the former. Even

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correct measures need appropriate time scheduling for their implementation and this is most effective if proper priorities are assigned.

The unsuccessful experience of many developing nations in their initial pollution abatement efforts has created the need for a more systematic approach. The principles described in this paper summarize the author's experience in this regard from his work with the Environmental Pollution Control Project-Athens and from his consulting missions to numerous developing countries as a WHO, UNEP, and Government consultant.

3. Objectives of the Initial Environmental Planning

The main objective of the initial environmental planning is to provide a specific and rational solution to the immediate problems of the pollution abatement authorities. Moreover, it establishes a better framework for the utilization of the available manpower and labs, and facilitates the monitoring of their performance. More specifically, the major targets are the following:

(1) Definition of high priority pollution control measures.

(2) Derivation of a realistic and effective strategy for pollution abatement.

(3) Derivation of basic land planning policies directing the geographic distribution of the industrial expansion.

(4) Design of the most effective strategy for monitoring the effluents and receiver water quality.

(5) Contribution towards the development of effective legislation by providing a clear strategy and philosophy along with the required effluent standards.

Before we consider in some detail the above points, we should examine first the collection of the necessary data and information which are required for the formulation of the environmental planning.

4. Inventory of Pollution Sources

The most important information for the formulation of the pollution abatement strategy is the knowledge of the size and location of the pollution sources, as well as, the identification of the receivers. The rapid pollution assessment methodology [1], [2], [3] is the most appropriate, as it allows systematic collection and processing of easily accessible data, minimizes the manpower and time requirements, yields most of the required information, and it can provide an acceptable degree of reliability.

In addition to the data collected within the framework of the rapid assessment methodology we would normally need more detailed information about each large source. This can be accomplished by rapid surveys in such key sources allowing more detailed calculation of the waste loads produced.

Based on our experience from a variety of situations, the number of major sources is very limited, even when a large number of plants operate. Thus for example, 5% of the existing plants may be responsible for more than 80% of the polluting loads

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generated by industry. This is important for it allows the study team to combine the rapid assessment techniques with a limited number of key visits in order to obtain quickly the kind of detailed information required for planning.

5. Economic, Technical and Organizational Constraints

In addition to the above inventory data a realistic environmental strategy takes into consideration the existing economic, technical and organizational constraints.

In the general case any waste treatment requirements must not impose an excessive burden so as to affect adversely the competitiveness and viability of industry, for otherwise the measures are impractical and very difficult to enforce. In the developing world this problem is more delicate since, as we have already mentioned, plants are often of much smaller size and hence the cost of treatment per unit of product tends to be higher than that in industrialized countries. Under such circumstances separate in-plant treatment of industrial wastes can be successfully imposed only on a rather limited number of major polluting plants. Fortunately, these plants, as previously reported, are responsible for the bulk of pollution.

The technical aspects associated with the proper maintenance and operation of the treatment installations is a very important constraint. Indeed, inadequate education and training of the operators and scarcity of scientists and engineers especially in smaller plants is a serious problem. The simplicity of treatment installations becomes most important, especially since operation of some treatment plants can be more sophisticated than the operation of the plant itself. Again, large plants are obviously in a better position to properly operate treatment installations.

Finally, when planning any control measures we have to consider the capability of the responsible authorities to have them enforced. It is well known that without the required expertize and facilities (laboratories, etc.) even reasonable measures fail to produce results. Indeed, while industries are in the process of obtaining permits for construction or expansion, it is often possible to have the installation of some kind of treatment plant imposed on them. Since however the performance cannot be checked the design is typically poor and the installation is rarely used. Thus, money is spent with minimal success.

From the above it would appear that for the initial phase of the environmental planning it is necessary to restrict waste treatment requirements on a small number of key plants since only then we satisfy simultaneously the existing economic, technical and organizational constraints.

In conclusion we could say that the pollution source inventory yields data which are necessary for establishing rational priorities in the waste treatment and monitoring requirements. Consideration of the economic, technical and organizational constraints shows where to draw the line so as to be successful in the implementation.

4

6. High Priority Waste Control Measures

During the inventory work it is often possible to identify relatively simple measures which can result in significant reduction of the pollution loads with small cost. For example:

(i) Establishing a scheme, which can be a simple one in the initial stages, for the collection and disposal of sludges and toxic or hazardous effluents can have a significant impact on the water pollution control efforts. This should provide acceptable solution to the disposal of sludges from wastewater treatment facilities, of oily and toxic sludges from storage of petroleum crude and products, of toxic concentrated solutions from certain types of production processes such as car battery manufacturing, electroplating, manufacture of chemicals such as pesticides etc. As a rule, absence of such a scheme results in significant direct or indirect water pollution.

(ii) Enforcement of proper operation on existing wastewater treatment facilities in major polluting industries could result in significant and immediate reduction of industrial pollution.

(iii) Separation and proper disposal of concentrated, toxic or hazardous wastes can, under certain conditions, yield an immediate, low cost and drastic reduction of water pollution. For example, separate disposal of spent solutions from electroplating baths, and of the blood and paunch from slaughterhouses, along with collection and recycling to the refinery of the spent lubricating oils from car service stations has reduced the toxic, oil, and BOD loads originating from an industrial area by roughly 30%, nearly 100% and 80% respectively.

(iv) Sometimes modification in the process or in the utilization of raw materials, for example, substitution of cyanide baths in electroplating operations, can also result in reduction of pollution.

(v) Striking cases or large polluters without any waste treatment, for example an alcohol distillery plant, may be good candidates for high priority control actions.

Generally, high priority waste control measures are very significant since through them we can achieve noticeable results within a very short time. At the same time we obtain the highest possible benefit to cost ratio.

Once the high priority measures for a given situation have been derived, we only need a limited verification before we can proceed into the implementation. Thus, it is possible to start our pollution control activities in a fairly early stage before the completion of the environmental planning process.

It should be stressed that the formulation of the high priority measures is not as simple as it may sound. The success of this important step depends very heavily on the skill and experience of the study team.

7. Waste Control Strategy for Existing Industries

We have seen that simultaneous satisfaction of the prevailing economic, technical and organizational constraints in developing nations can be accomplished through careful

5

selection of a small number of key sources on which to impose waste treatment requirements. This is the principle based on which we can proceed to develop systematically our strategy.

For industries discharging into the sewer system of a city we can take advantage of the central treatment plant, if any, for combined treatment. Of course, the quantity and character of such effluents must be suitable for combined treatment, but this is not a problem for most small and medium size plants within large cities. The advantage of this case is the low cost of the combined treatment (the size of the treatment plant is big, thus the cost per unit volume of waste is small). Moreover, the highest possible operating reliability along with the lowest supervision requirements from the pollution control authorities are obtained.

Some of the industries connected to sewer systems will be required to have in-site pretreatment for their wastes. It is important to limit such pretreatment requirements only to industries with toxic or hazardous wastes, and among those to further select the large ones.

The effluent standards for such industries connected to domestic sewer systems can be fairly simple. Limits for toxic and hazardous components can be common for all types of industry. However, for each type of industry the minimum plant size subject to such restrictions must be specified. The inventory data along with an overview of the existing economic, technical and organizational constraints can lead fairly quickly into a realistic set of standards that express precisely the most effective policy for each particular situation.

For industries in industrial zones the most beneficial policy can be the optimization of the combined treatment along with the careful selection of pretreatment requirements as for industries connected to domestic sewer systems.

Among industries discharging directly into the receivers we must very carefully select those that are responsible for the bulk of pollution, the effluents of which must be treated. The number of such industries must be necessarily limited so that again the existing economic, technical and organizational constraints are satisfied.

The effluent standards in this case should vary from industry to industry (a tannery for example must have different standards than a dairy and should apply only for industries larger than a minimum specified size). It can be seen that such standards cannot be copies of those employed in other countries. Instead they should express absolutely a realistic strategy, which satisfies best the local needs within the existing constraints.

The escalation of the imposed measures in time, an important element of the waste control strategy, can be achieved both for industries connected to domestic sewer systems and for those discharging directly into the receivers through progressive reduction of the specified minimum plant size, above which treatment is imposed. Along with that, a progressive relaxation of the treatment requirements may be found necessary as we deal with smaller and smaller plants. This way, we ensure that the first waste treatment installations are to be imposed on the most important sources, and in the course of time, always on the most important of the remaining ones.

6

8. Organization of an Effective Waste Monitoring Program

The initial target of the waste measuring program is to improve the accuracy of the rapid assessment results, since in the latter case the estimate of the waste volumes and loads is based on the accumulated experience from the operation of other similar processes and on statistical averages [2]. We should however realize that such an improvement is conditional and to illustrate this we should consider the following:

(a) Many industrial operations do not have a constant operation. Their process activities follow cycles which last from a few hours (e.g. 8-hr cycles in textile mills) to a few days (e.g. 4 to 7 day cycles in tanneries). Moreover, there are annual cycles with seasonal or irregular variations (e.g. fruit and vegetable canneries or textile mills processing more wool in the winter and more cotton in the summer). During these cycles the rate and characteristics of the wastes may change appreciably and hence, many samples and careful work is required to provide accurate results.

(b) Sampling and analysis itself can be subject to considerable errors, especially when new labs are involved and toxic substances are measured.

Based on the above we could say that hasty waste sampling and analysis does not necessarily improve the accuracy of the rapid assessment results. Our experience shows the contrary. Thus, in order to get better results we must be prepared to devote the necessary effort and to make a systematic plan for every source we measure.

Obviously, as a great number of industrial waste sources normally exist, the amount of work required to survey properly all sources in a given area becomes prohibitive, especially under the lab and skilled personnel limitations which often exist in developing nations. This problem can be solved only through careful planning of an effective monitoring program.

Indeed, through the rapid assessment of the waste sources we have data about the total waste loads generated and the contribution of each individual key industry. It is thus relatively easy to set priorities in our waste survey program concentrating first on the large polluters. We have already seen that in most cases a small number of key sources account for the bulk of the pollution problem. Thus, within a short time we can monitor reliably the streams that cause most of the problem, while relying on the rapid assessment results for the great number of sources the combined contribution of which is of secondary importance. It should be noted that careful monitoring of key sources provides first hand data for the plants that are the most likely receivers of waste treatment restrictions. Thus, we are in general agreement with the overall planning objectives.

Advantage of the rapid assessment results can be also taken in order to define the parameters which are necessary to measure for each kind of plant during the waste survey exercise. This can reduce considerably the overall survey effort, while improving the completeness of the results. It should be noted that in practice we have often encountered the situation where the waste of many plants have been measured through grab samples analysed for a standard set of parameters irrespective of the kind of process involved. Thus, BOD might have been measured in electroplating process samples and heavy metals could have been sought in wastes from dairies.

9. Organization of an Effective Receiver Water Monitoring Program

The data collected in the course of the environmental planning exercise, especially those from the rapid assessment, allow the organization of effective monitoring programs for the waste receiving waters. Indeed, information about the discharge points and the distribution of the polluting loads is available by the planners, and this coupled with more general considerations about the character and importance (current or intended use) of the receiver waters provide the basis for organizing rapidly a rational monitoring program. In this, the key sampling locations, the parameters to be measured and even the sampling frequencies can be specified realistically within the existing constraints.

It should be pointed out that in most cases of water survey programs, even in exntensive ones, there is not a direct input of inventory results into their planning. This could be explained by the fact that inventories and water surveys are usually performed by different services and by people with different backgrounds without adequate contact and overall coordination.

10. Rational Location of New Industries

The derivation of a landplanning policy for the industrial activity is fairly complex as political, economic, technical and environmental criteria are to be considered. From the water pollution point of view, the results of the rapid assessment methodology can provide valuable input as they yield the magnitude of the expected pollution loads in the early planning stages.

In conjunction with the above information, consideration of some simple rules, such as the following, goes a long way towards the derivation of an environmentally sound policy:

(a) Surface waters are usually the most sensitive waste receivers and they become an ever more valuable national asset. Creation of industries with potentially significant discharges into such waters should be avoided. However, if other factors prevail, the existence of the economic, technical and organizational requirements for adequate waste water treatment must be ensured.

(b) Heavy industries, even if they can meet (because of their size) environmental requirements, often attract smaller industries around as a result of the available business, skilled labor and infrastructure. These secondary plants could end up creating significant and difficult to control problems, unless care is taken in time to have them located in appropriate industrial zones.

(c) From the liquid wastes point of view, the best location of smaller and medium size polluting plants are sewered areas. As we have seen, combined treatment of such industrial and domestic wastes is economically advantageous, while providing operational reliability.

(d) Small industries with similar toxic or hazardous wastes should be grouped together so as to maximize the possibilities for combined waste treatment or pretreatment. This is the only practical way for such small plants to effectively control their effluents.

8

11. The Environmental Planners

One of the most significant drawbacks in the environmental program of most developing nations is the lack of a coordinating body entrusted to formulate the environmental policy and supervise its implementation.

This body should have direct authority over the work produced by each environmental service. Close contact and cooperation with each service will generate all information required for a comprehensive environmental program. Within the framework of the program the operation of all services can be coodinated in the most effective way and their progress can be monitored and evaluated.

Relatively few people are required to staff such a body. Quite clearly however, their caliber must be the highest available as their work will leave a long lasting impact.

12. Implementation/Problems and Politics

Even the best of the pollution abatement strategies cannot be fully implemented unless the government truly wants it so. For it should be willing to impose the proper measures on the large firms and to support with loans and subsidies, especially the smaller ones. What is more, it should be prepared to spend whatever sums of money will be required for foreign imports and overcome the fear that such pollution control efforts will slow down industrial growth.

This fear is indeed real and is expressed by the dominating role of the economic ministeries over the pollution control activities.

In most cases, the most important element that convinces politicians to overcome the above drawbacks and proceed with meaningful pollution abatement programs is the public awareness of the pollution problem. Once pollution issues get continuous and high publicity and once public concern or discomfort reaches accute levels, then conditions are truly ripe for real action. Of course, some restricted pollution abatement activity may always exist for political and economic reasons (in order for example to maintain acceptable sea water quality in touristic areas) but this often falls too short to solve the overall problem.

It may be interesting to note that effective action to combat pollution of one sort (e.g. air pollution) often sensitizes the public and the government to effectively tackle all kinds of pollution problems.

From the above it would appear that pollution control in developing countries is generally not preventive. Once conditions are ripe, pollution control authorities are in a crisis having to develop strategies and implement measures in the shortest possible time. It is under those conditions, now present in Greece, that the proposed methodology can provide maximum help.

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9

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