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AN APPROACH TO ESTABLISHING EFFLUENT GUIDELINES AND EVALUATING PLANT PERFORMANCE

Effluent discharge permits — in order to be effective — have to include the objective difficulties that are experienced by the manufacturing industrial plant with the product mix raw materials quality and other variabilities. The changing conditions at the effluent treatment works — affected by the manufacturing plant and by seasonal variations, etc., as well as the development of more refined treatment technology have to be taken into account. An approach is presented that allows the water quality authority to assess the value of raw waste loading (RWL) and available treatment technology to reduce the RWL to limits acceptable for discharge to the receiver. The major elements in the analysis are: definition of the RWL based on characterization of the industry and placement of the individual polluter on this spectrum, after defining the possibilities of in-plant changes; wastewater treatment technology availability and variation of the effluent quality due to all effecting factors.

The permits for discharge of wastewaters to surface waters in Poland are issued on a combined immission-emission approach, with greater emphasis placed on immission, except for the hazardous or toxic materials, where emission is determined. When issuing a permit, the water pollution control authority takes into account several factors based on the knowledge of the polluter's age, location, type of production and evaluates the feasibility of attaining the reduction of the pollution load by means of available technologies. In practice three types of treatment trains are taken into account: the presently used technology (PUT), the best practically attainable technology (BPT), and the best available one (BAT) — usually regarded as the goal technology.

Noting the efforts already made by some countries in evaluating the effluent guidelines for various key industries and the difficulties in attaining a constant effluent quality from the PUT plants as well as the BPT plants, the environmental protection authorities are required to establish provisions for differentiating the criteria relevant to various polluters.

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The paper presents an approach to setting wastewater discharge standards for individual polluters and groups within an industry. The method has been recently presented [10] for discussion within the Baltic Sea States Convention (the 1974 Helsinki Convention) as it serves the purpose of giving a clearcut procedure assissting in determining allowable discharge at a given manufacturing and wastewater treatment technology level — at the same time including the inherent variability of effluent quality. The procedure, in a different form has been used in defining the allowable raw waste loading (RWL) and treated effluent quality for several industries [5, 6, 12].

Finally, the paper will present an approach to appraisal of existing waste treatment plants efficiency as used in this country, although the procedures are not officially binding.

2. DEFINING THE MATRIX PROCEDURE

The so-called matrix method is a procedure to define alternative solutions for the establishement of effluent guidelines. In practice, the procedure (which is not a matrix in mathematical sense) involves the use of three matrices, as shown in fig. 1 (AS — activated sludge, TF — trickling filter, LD — land disposal, AC — activated carbon). The first matrix leads to the definition of the raw waste load (RWL). This is then fed into the second matrix which yields alternative choices of BPT with the resulting effluent qualities. These options are then applied to the economic matrix which results in a series of cost versus effluent quality relationships for end of pipe treatment using the raw waste load defined by the first matrix. Iteration of the procedure can be made by including in-plant changes to alter the raw waste load and resulting cost comparisons for in-plant modifications versus the end of pipe treatment. It should be emphasized that the reliability of results obtained by this procedure is highly dependent on the data base available. In many industrial categories the data base available at present is very poor and the results obtained by applying this procedure are correspondingly weak. This procedure clearly defines what data are necessary in order to develop meaningful results which can be applied in practice with confidence. While these defficiencies are recognized any procedure or methodology that might be applied at present to establish effluent limitations suffer from the same data base deficiencies.

3. DEFINING RAW WASTE LOADING (RWL)

For a given industrial category statistical plots are developed for the pertinent wastewater parameters, e.g. m^3/unit production, kg BOD/ton production, etc., taking into account the obvious criteria that would influence the RWL, such as plant age, etc. which are determined by plotting the mean values (50% frequency) from the probability plot versus the pertinent variable. If one of these factors shows a significant effect on the RWL,

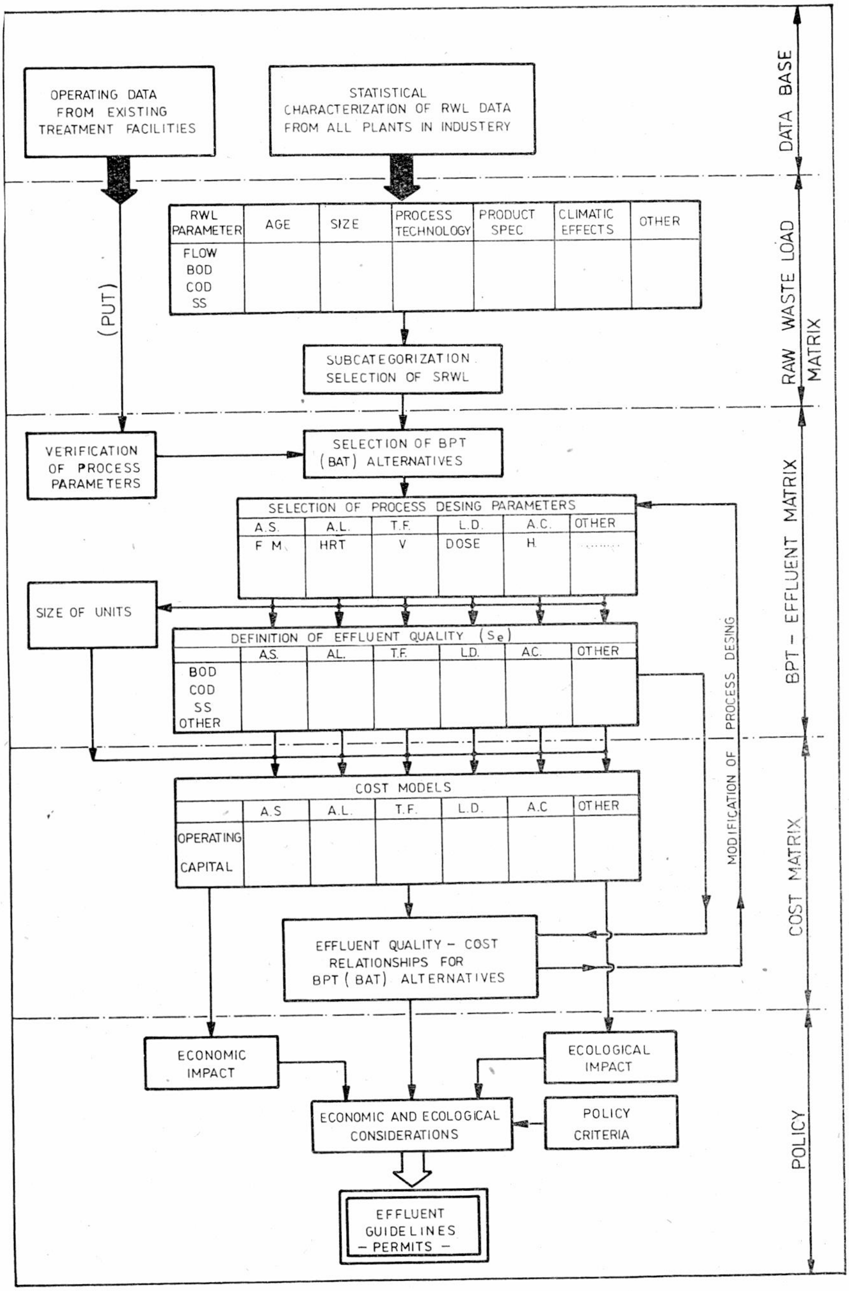

Fig. 1. Permits of effluent guidelines development matrix

Rys. 1. Proponowany schemat opracowania kryteriów zrzutu zanieczyszczeń reasonable groupings are selected and a statistical plot of all plants in that group is developed. For example, if plant size has a significant effect on the volume of wastewater per unit production generated, two or more size groupings can be selected, depending on the number of plants in the category and the degree of variation. This procedure then defines subcategories for determination of the RWL.

An example of such a case is presented in fig. 2, where in log-probability scale various RWL are plotted assuming [5] log-normal distribution. One point represents one potato processing plant in the U.S.A. It is evident that two operations: the frozen potato and

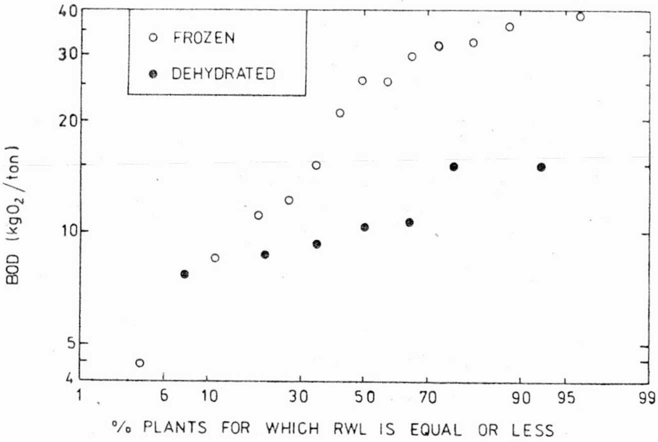

Fig. 2. Variation of RWL with potato processing category

Rys. 2. Zmiany ładunku ścieków surowych w różnych sektorach przemysłu ziemniaczanego

products and dehydrated potato and products call for two distinct subcategories.

If a grouping of plants still falls far off the ranges discussed, indicating that any factor other than size or age is significantly influencing the RWL, further investigation should be made on those plants in order to define differences occurring in practices between the plants in the category which may account for the variability. Other factors which may influence the raw waste load are changes in processing equipment, changes in the product mix or end product specifications.

The procedure to this point yields one more probability plot of mean RWL for all of the plants surveyed in the industry. Each probability plot may represent a subcategory in the industry.

There exist several alternatives for the selection of a standard raw waste load (SRWL) for the subcategory. It is assumed that a significant part of the RWL variability is due to in-plant practices, water re-use, good housekeeping, etc. Data are generally not available at this time, however, to define in-plant practices, processing variation, and differences in product mix which may account for the differences between plants in a given subcategory. In order to establish a SRWL or set an examplary plant-ongoing efforts should be directed toward the impact of various in-plant practices on the RWL and their associated costs. It is recognized that time will be required in order to define these variables and their effect on the RWL. In order to define a SRWL for the present permit-issuing procedures, it is suggested that one standard deviation from the mean of the probability plot be selected as the standard RWL. It is assumed when selecting these values that all plants with a RWL different from the one standard deviation might, by reasonable in-plant control, reduce their RWL to this level or below [5, 12].

4. WASTEWATER TREATMENT TECHNOLOGY

The second matrix involves the definition of BPT and end of pipe wastewater treatment-technology. Defining Best Practical Technology (BPT) involves selecting wastewater treatment processes applicable to the industrial category and the effluent qualities obtainable by that technology. In all cases, constraints are imposed on the processes to insure dependable process performance, and in some cases land limitations occur in terms of availability or cost. Studies are confined to three or four secondary wastewater treatment technologies, namely the activated sludge process, the trickling filter, the aerated lagoon, and spray irrigation. The following technical details relate to some of these processes. The same procedure may be applied to other wastewater treatment processes such as chemical coagulation, activated carbon adsorption, etc. The present know-how of the anaerobic treatment of dilute wastewaters justifies including them in these considerations.

The effluent quality attainable in activated sludge process is defined in terms of BOD, COD, and suspended solids. Depending on the wastewater in question, other parameters such as nitrogen, phosphorus, metals, phenols, etc., may also be defined. For the activated sludge process to be performed efficiently, it is necessary to impose constraints. These constraints define a minimum effluent soluble BOD_5 of 10 mg O_2/dm^3, a minimum F/M (sludge loading) of 0.2 kg O_2/kg MLVSS· d, a maximum F/M of 0.5 which may vary somewhat depending on waste type. The maximum F/M is a function of the characteristics of the wastewater, primarily its biodegradability. A highly biodegradable wastewater such as from brewery or sugar refinery may have a maximum F/M as low as 0.35 in order to avoid the generation of filamentous non-settling growth. The soluble effluent BOD is related to the reaction rate coefficient k and may be calculated for example from the Grau, Eckenfelder formula [3]:

$$\frac{(S_0-S_e)}{X_v \cdot HRT} = k\frac{S_e}{S_0}$$

where S_e, S_0 are effluent, influent concentrations; X_v are MLVSS (active biomass); HRT is hydraulic retention time.

For any wastewater having defined the BOD removal rate coefficient k, a relationship may be developed between soluble filtered BOD_f remaining and the organic loading F/M

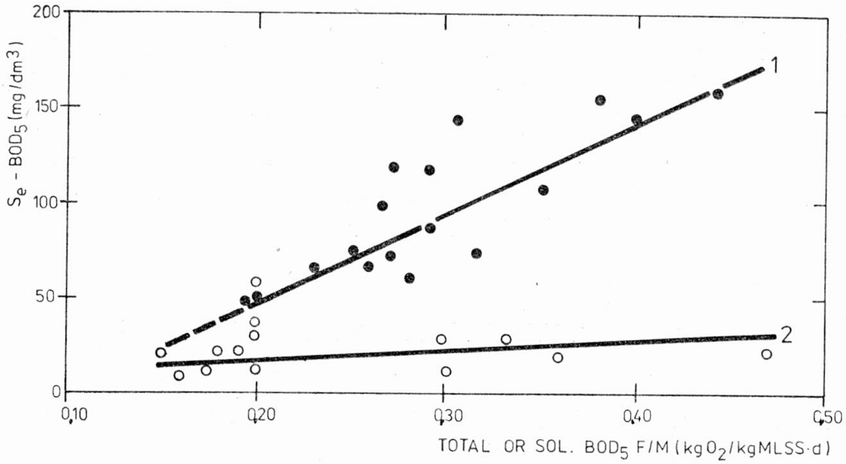

Fig. 3. Effluent BOD_5 versus F/M — piggery wastewaters

1 — total BOD data (BOD_{nf}), 2 — soluble BOD data (BOD_f)

Rys. 3. BZT_5 odpływu z komory osadu czynnego w zależności od obciążenia osadu — ścieki z tuczarni przemysłowej

1 — BZT całkowite, 2 — BZT rozpuszczalne

(e.g. references [6, 7]). The thing of primary concern to the regulatory agency and one that affects the permit is the nonfiltered $BOD_{5,nf}$ of the effluent, which is composed of the soluble $BOD_{5,f}$ and that contributed by the effluent suspended solids (SS). $BOD_{5,nf}$ can be computed from the relationship $BOD_{5,nf} = BOD_{5,f} + f \cdot SS$ in which f is the mg of BOD per mg of suspended solids and is a function of the sludge age in the process. For activated sludge processes operating over F/M range of 0.2 to 0.5, f was found approximately equal to 0.3 for various wastes [7]. The increase in F/M results in an increase of the solids carryover and the increase of nonfiltered BOD_5 — as illustrated in fig. 3.

Over the appropriate loading range with a properly designed final clarifier and a low total dissolved solids (TDS) in wastewater, the effluent suspended solids can be expected to range from 20 to 30 mg/dm^3.

The effluent suspended solids can be expected to increase in relation to an increase in TDS. The effects of TDS and chloride salinity are presented in fig. 4 for two industries. These SS (fig. 4A) are non-settlable and independent of the final clarifier loading. The effluent suspended solids will also increase due to sludge bulking when the process is operated beyond its effective F/M range.

Temperature will also affect the effluent suspended solids which increase with the decrease of temperature in aeration basin. For any industrial wastewater, it is necessary to define the effluent suspended solids characterisctics, differentiating between settleable and non-settleable suspended solids. Settleable suspended solids should be maintained over a range of 20 to 30 mg/dm^3, whereas non-settleable suspended solids are a function of TDS and temperature. Fig. 5 presents such variability for one hardboard processing

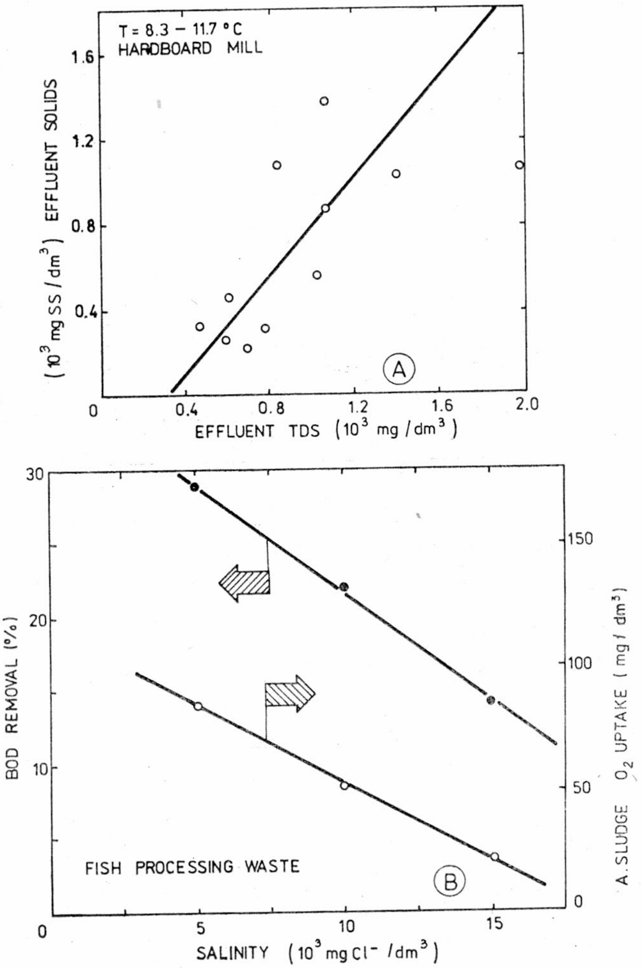

Fig. 4. Effects of dissolved solids on effluent quality

A. aerated lagoon effluent solids as affected by TDS, B. activated sludge BOD removal as affected by chloride content

Rys. 4. Wpływ związków rozpuszczonych na jakość odpływu

A. wpływ związków rozpuszczonych całkowitych na odpływ zawiesin z laguny napowietrzanej, B. wpływ chlorków na usuwanie BZT w procesie osadu czynnego

plant effluent from an aerated lagoon which is the basic secondary treatment process in the wet hardboard manufacturing industry in the US [6]. It is evident that significant differences exist in two seasons with diametrical temperatures — due to waste treatment plant operational variability. The effect of temperature is further emphasized by the relationships in fig. 6 for two aerated lagoons in a northern climate.

The effluent COD will be a result of residual BOD and non-degradable (refractory) organics present in wastewater and generated through the process. The effluent COD can

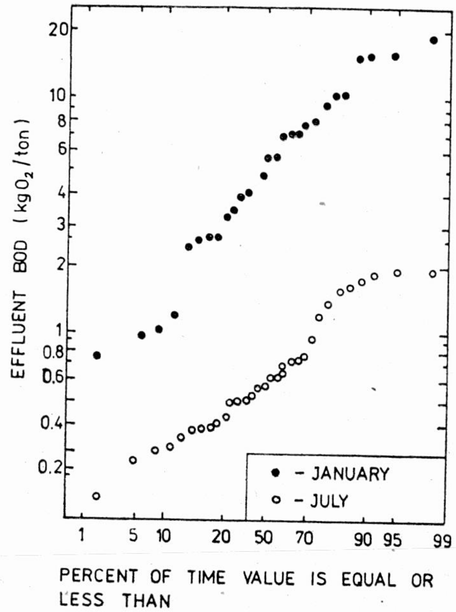

Fig. 5. Seasonal variations of the effluent load discharged from an aerated lagoon treating hardboard wastes

Rys. 5. Zmiany sezonowe zrzucanego ładunku zanieczyszczeń z laguny napowietrzanej pracującej na ściekach z produkcji płyt pilśniowych

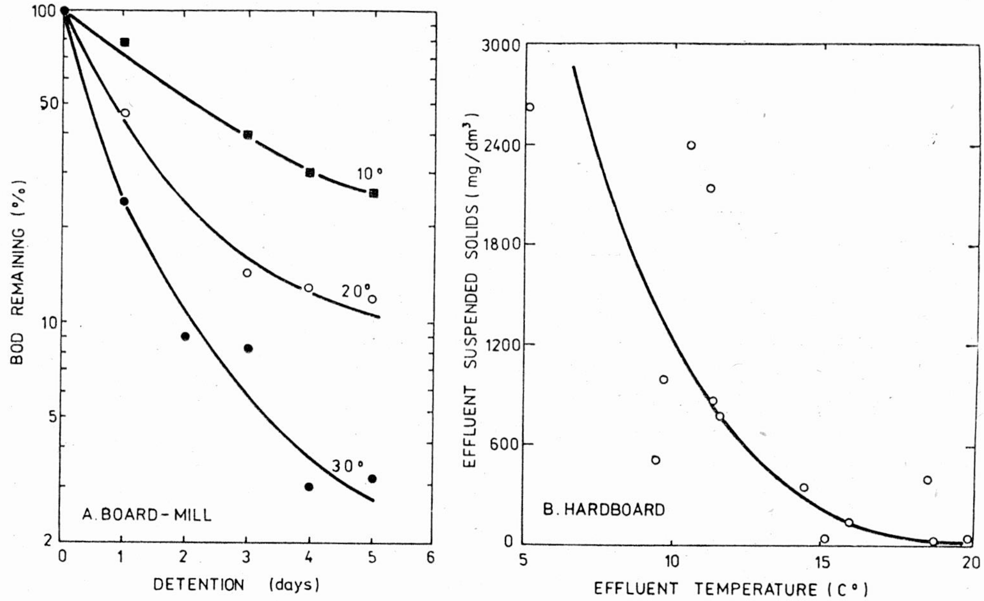

Fig. 6. Effects temperature on (A) — BOD removal in activated sludge and (B) — effluent suspended solids in aerated lagoon

Rys. 6. Wpływ temperatury na (A) — usuwanie BZT w procesie osadu czynnego, (B) — zawartość zawiesin w odpływie z laguny napowietrzanej; ścieki z produkcji płyt pilśniowych be computed from the ultimate BOD_u removed. COD and TOC should be used by regulatory agencies along with BOD for all industrial wastes.

Similarly, trickling filter data may be handled. Care should be taken here since various models available may lead to errors extending to 1000% and more when calculating the required volume [11]. The performance should be evaluated by analyzing the base plant data and using a correlation model, such as the one proposed by OLESZKIEWICZ and ECKENFELDER [8]:

$$S_e/S_0 = \exp(-K/L) = \exp(-kA\theta^{\Delta T}/S_0\,Q) \tag{2}$$

which may be presented in another form:

$$S_e/S_0 = \exp-\left(\frac{-K}{F/M}\right). \tag{3}$$

Pretreatment must be considered for all biological processes in order to render the wastewater compatible with the biological system. Pretreatment processes may include:

a) equalization to maintain the range of variability of the wastewater characteristics within defined limits;

b) neutralization to maintain the pH within limits compatible with the biological process;

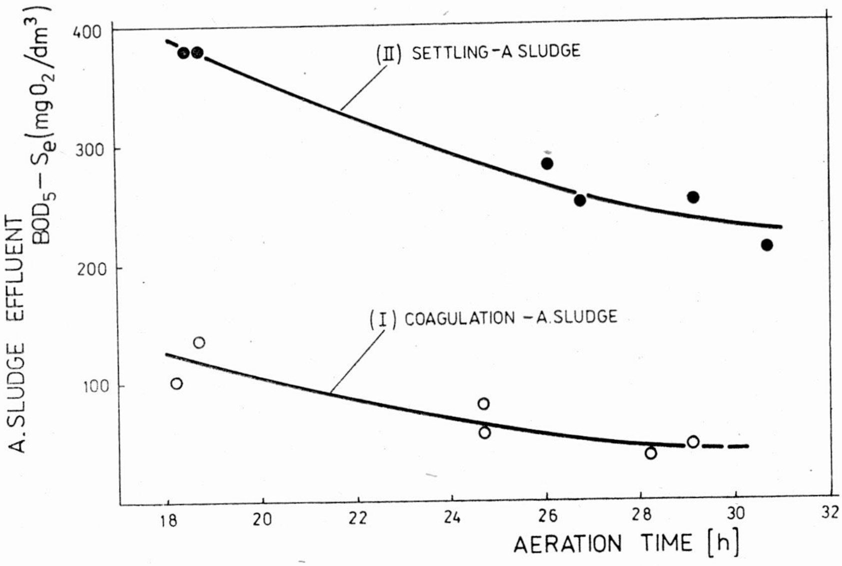

Fig. 7. Effects of two pretreatment methods on activated sludge process performance — piggery wastewasters

Rys. 7. Wpływ różnych metod podczyszczania na efektywność osadu czynnego — ścieki z tuczu trzody chlewnej

c) oil and grease removal;

d) sedimentation or flotation for the removal of suspended solids or floating solids;

e) chemical coagulation for the removal of heavy metals or inhibitory compounds (fig. 7);

f) adsorption of toxic (polar) compounds.

Recycle must always be provided to make the effluent reliable and stable — it is a prerequisite for all industrial biofiltration plants [9].

Having defined pretreatment requirements and the volume requirements for various effluent qualities, the process models can be integrated with appropriate cost models in order to develop a relationship between cost and effluent quality.

5. PROCEDURE FOR DETERMINATION OF EFFLUENT LIMITATION AND ISSUING EMISSION PERMITS

1. Statistical plots should be developed for all pertinent RWL parameters within an industrial category or municipality.

2. In case of municipal agglomeration mean values [1] are used to determine if age or size of facility have an effect on RWL or other pertinent factors.

3. Extreme values from [1] will usually be due to variation in housekeeping and reuse practices. For example, removal of pollutants in a semi-dry state in tomato processing and storage tank sediments from the breweries will affect the BOD loading but not the flow. Process changes such as the installation of condensate stripping in bleaching kraft mills will reduce the BOD loading and the flow if this water is recycled. Some of these practices include little cost and should be considered in defining the SRWL. Others involve significant cost and should be considered as alternative to end-of-pipe-treatment. Some are a prerequisite prior to applying the BPT or BAT (e.g. concentration of wastes prior to anaerobic treatment).

4. A SRWL is determined for each sub-category as defined by (1) to (3) above.

5. Wastewater treatment processes applicable to the category in question are selected. These will be processes or combinations of processes in practice today, capable of meeting secondary standards. The process models will be developed including any necessary pretreatment and the constraints on the process and the effluent quality, e.g. the F/M range, the TDS level etc. The effluent quality is then computed over the appropriate range.

6. Effluent quality for various ambient temperature conditions are calculated. Process selection limitations due to geographic constraints are made (e.g. spray irrigation may not be BPT in northern Finland, while it is an optimum choice in the southern area in Poland).

7. The results from (5) and (6) are combined with the cost models to develop cost vs. effluent quality relationships (process optimization).

8. The results at this point can be employed for a number of purposes:

a) Economic equity in which the cost/unit production is kept constant. This will usually yield a different BPT and resulting effluent quality for different size ranges.

b) Determination of cost-effective treatment level, generally defined as that effluent quality above which the cost inordinately increases. There are several possible approaches to achieving this value.

9. Variability in effluent quality is determined by combining the results of (4–6). Methodology to achieve this effectively is presently under study.

10. An effluent limitation is generated from consideration of (7–9) above.

6. APPROACH TO APPRAISAL OF WASTE TREATMENT PLANT EFFICIENCY

The current legislation [1, 2] does not specify the exact method for conducting surveys determining the load discharged and assessing the wastewater treatment plant performance. In practice the routine control is based on data provided by the discharger's laboratory (the frequency, place and method of sampling are specified in the permit). Random check-ups are made by the environmental protection service and in case of suspected violations round-the-clock monitoring surveys are ordered.

In order to obtain a permit and define effluent quality, as well as to determine the technology of plant performance the polluter requires the service of specialized design office study groups which conduct a survey for an extended period of time. In one typical case the wastes from a large railway cars washing plant were sampled on six different site trips, each 3 days long on 24 h/d basis, encompassing the broad spectrum of materials transported, seasons, etc.

In order to find the best method for evaluating the treatment plant performance a study was run [4] on the methods used for appraisal and their accuracy. Three wastewater treatment plant (WTP) were selected: plant A — a combined (50% industrial wastes) WTP for 15000 m^3/d, plant B — a predominantly municipal (95% sewage) WTP for 2500 m^3/d, and plant C — tannery WTP for 220 m^3/d. Plant A used conventional activated sludge, plant B — trickling filtration, and plant C applied chemical precipitation (alum) to equalized wastes.

Two types of samples were collected: *primary* collected every 1 or 2 hrs for 24 hrs, and *proportional* obtained by mixing the primary samples according to the wastes flow-rate in time of sampling. Data analysis (full physico-chemical analyses were run) consisted in determination of hourly flows, concentrations and loads, daily cumulative flows and loads, and the heterogeneity of flow and concentration coefficients (i.e. ratio of hourly to daily average flow, etc.). Comparison involved extreme values, arithemtic means, weighted means — i.e. cumulative daily load divided by cumulative daily wastewater volume and values of the concentration of the proportional sample — i.e. the one made from primary samples mixed according to the flow volume. The conclusions can be itemized as follows:

While comparing extremal concentrations, which are likely to be encountered during random sampling, the deviation from the weighted mean accounted to 17–492% for raw wastes and 4–105% for treated wastes. The deviation of the arithmetic mean from the weighted mean was 3–17% for raw and only 0.1–5% for treated effluent.

The smallest error occurs when analyzing the proportionally mixed samples. Comparison of proportional to weighted means yielded 1–3% (raw) and 0.4–4% (treated) differences.

The error increases in relation to the increase of the sampling interval: the increase of error in estimating the daily load amounted to 10–68% (raw) and 2–4% (biologically treated) and 16% (chemically treated) for the doubled sampling interval.

The error in daily load calculation based on three samples (selected on the basis of the random numbers table) amounted to 38% for raw and 8.5% for treated wastes.

The efficiency of COD removal in the three WTP presented in table 1 indicates that the method to be selected in case of short-term extensive surveys is the calculation of loads (both RWL and treated) on the basis of the proportional samples, i.e. mixed proportionally to the flow rate.

Table 1

Comparison of effects of two methods of appraisal of WTP removal efficiency – COD data [4]

Porównanie wyników dwóch metod oceny efektywności usuwania zanieczyszczeń przez oczyszczalnię ścieków – dane ChZT [4]

Kind of sample	Waste treatment efficiency (%)		
	Plant A	Plant B	Plant C
Mean weighted	90.2	76.9	75.7
Proportional sample	90.1	78.0	77.1
DIFFERENCE	0.1	1.1	1.4

In this country automatic samplers used in practice are capable of being programmed for collecting 48 samples in the time of 12 hours to 7 days (collection and refrigeration). The study [4] indicates that the calculation of the data based on weighted means values is adequate and will yield results with insignificant error.

Usually, when a large number of samples are analyzed over a prolonged period of time, then a method of normal probability distribution is used (log-normal if necessary) to determine the mean (50 percentile) and the extremes (10 and 90 percentile) for design purposes.

An example of statistical analysis of a physico-chemical-biological treatment plant efficiency is given in [7]. Efficiences of two large piggery wastewater treatment plants were compared. Plant I had a much more diluted raw influent than Plant II. The figure enables to notice the poor performance of activated sludge in Plant II. It should be noted that both plants had identical process layouts, which encompassed dynamic screening, preaeration, chemical coagulation, activated sludge treatment, anaerobic biofiltration, and disinfection.

The data were collected annually — four times a day — proportional sample was made only for screen effluent analysis as preaeration gave a 24 hour retention and the subsequent samples were collected according to the time of passage through the unit processes. Flow rate is measured at the pumping station and by weir and limnigraph in the chlorine contact tank. The waste treatment trains process 300–900 m^3 of wastes/d; the plants have one full time employee for the analytical control of plant performance trained by environmental protection service personnel. Analysis of statistical data in this case has revealed the poor performance of activated sludge in Plant II, due to hydraulic overloading and indicated other areas where specialized assistance was necessary.

7. SUMMARY AND CONCLUSIONS

It has been demonstrated that elaboration of uniform standards for issuing permits to individual polluters is a complex process. However, it could be technically solved much easier if a large data pool was created on plant performance in the various industrial sectors allowing to analyze the present plant operation and the development trends and then apply a method similar to the one presented here.

So far there are no systems that can effectively take into account all factors affecting the relationship between the raw waste loading and effluent quality from the treatment plant; that would at the same time encompass all other pertinent factors such as climate, geographic location, economics, forecasted trends, size and importance of the plant and a host of non-economical factors that can be judged but that are difficult to quantify. The presented approach offers a method that, if based on a large number of data collected directly from the industry, produces results less biased than the other approaches used so far.

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METODA USTALANIA DOPUSZCZALNEGO STĘŻENIA ZANIECZYSZCZEŃ W ODPŁYWIE ORAZ OCENY PRACY OCZYSZCZALNI ŚCIEKÓW

Pozwolenie na zrzut zanieczyszczeń jest wtedy efektywne, gdy uwzględnia różnice w składzie surowców, asortymencie produkcji i wynikające stąd wahania ładunku ścieków surowych (ŁSS). W pracy zaproponowano metodykę postępowania dla ustalenia kryteriów zrzutu zanieczyszczeń, biorąc pod uwagę zróżnicowania w technologii produkcji zakładów przemysłowych i kładąc szczególny nacisk na konieczność uwzględnienia nierównomierności w jakości odpływu ścieków oczyszczonych wskutek zmienności asortymentu produkcji, wahań temperatury, zrzutów incydentalnych i błędów eksploatacyjnych.

Zwrócono szczególną uwagę na zależność efektów oczyszczania ścieków od zmian technologii produkcji i (w przypadku procesów biologicznych) od pory roku, od metod podczyszczania zawartości związków rozpuszczonych oraz od obciążenia urządzeń ładunkiem związków organicznych i zawiesin.

W końcowej części pracy przedstawiono porównanie metod oceny efektywności pracy oczyszczalni ścieków. Z porównania tego wynika, że najdokładniejszą ocenę pracy daje analiza wyników prób pobieranych proporcjonalnie do wielkości przepływu. Przedstawiono wpływ metod analizy wyników na wielkość odchylenia od wyniku z prób proporcjonalnych do przepływu oraz możliwość zastosowania metody statystycznej (rozkładu normalnego) do oceny efektywności na bazie wielkiej liczby wyników prób przypadkowych.

EINE METHODE ZUR FESTLEGUNG DER ZULÄSSIGEN VERSCHMUTZUNGSKONZENTRATION IM ZUFLUSS SOWIE ZUR BEURTEILUNG VON ABWÄSSERREINIGUNGSANLAGEN

Die Genehmigung für die Abgabe von Verschmutzungen ist nur dann effektiv, wenn Unterschiede in der Substratzusammensetzung, in der Produktionsart und die daraus resultierenden Schwankungen der zufliessenden Abwasserlast (LSS) in Betracht gezogen werden. Vorgeschlagen wird ein Vorgehen zur Bestimmung der Abgabekriterien, die die Unterschiede der industriellen Produktion auswerten; zu diesen gehören:

die Schwankungen der Abwasserkonzentration als Folge der sich ändernden Herstellungsverfahren, die Schwankungen der Temperatur, inzidentale Abflüße und Betriebsfehler.

Besonderer Augenmerk wurde den Abhängigkeiten des Reinigungsgrades von der Produktionsabänderung und (bei biologischen Verfahren) von der Jahreszeit, von der Vorreinigung, vom Inhalt der gelösten organischen Substanz sowie von der Anlagenbelastung geschenkt.

Zum Schluß wurden verschiedene Methoden zur Beurteilung der Effektivität der Kläranlagen miteinander verglichen. Aus diesem Vergleich geht hervor, daß die genaueste Bewertung nur dann möglich ist, wenn die Proben proportional zum Durchfluß entnommen werden. Auch die Art der Auswertungsmethoden spielt eine wesentliche Rolle. Bei großer Anzahl der zufälligen Analysen kommen statistische Methoden (Normalverteilung) voll zur Geltung.

МЕТОД ОПРЕДЕЛЕНИЯ ДОПУСТИМОЙ КОНЦЕНТРАЦИИ ЗАГРЯЗНЕНИЙ В ПРИТОКЕ, А ТАКЖЕ ОЦЕНКИ РАБОТЫ СТАНЦИИ ОЧИСТКИ СТОЧНЫХ ВОД

Разрешение на сброс загрязнений является тогда эффективным, когда оно учитывает различия в составе сырья, ассортименте производства, а также вытекающие отсюда колебания запаса сырых сточных вод (ЗССВ). В работе предложена методика процедуры определения критериев сброса загрязнений при учёте дифференциации в технологии производства промышленных предприятий. Особенный упор делается на необходимость учёта неравномерностей в качестве стока очищенных сточных вод, возникших вследствие изменяемости ассортимента производства, колебаний температуры, случайных (побочных) сбросов и эксплуатационных ошибок.

Особое внимание уделено зависимости эффектов очистки сточных вод от изменений технологии производства и (в случае биологических процессов) вфемени года, от методов подочистки содержания растворённых соединений, а также от нагрузки установок запасом органических соединений и суспензий.

В конечной части работы приведено сопоставление методов оценки эффективности работы станций очистки сточных вод. Из этого сопоставления следует, что наиболее точную оценку работы даёт анализ результатов проб, отбираемых пропорционально величине расхода. Указано влияние методов анализа результатов на величину отклонения от результата из проб, пропорциональных расходу, а также возможность применения статистического метода (нормального распределения) для оценки эффективности на основе большого числа результатов случайных проб.

RECTIFICATION

The authors of the paper *Possibilities of water utilization for cooling purposes after its renovation process* — published in *Environment Protection Engineering*, Vol. 5 (1979), No. 4, pp. 397–406 — are MARIA ZDYBIEWSKA and MARIA JANOSZ-RAJCZYK, affiliated with the Environment Protection Engineering Institute, Silesian Technical University, Pstrowskiego 5, 44–100 Gliwice. We are very sorry for the error.