Environment Protection Engineering

Vol. 6 1980 No. 2

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ENVIRONMENTAL EFFECTS OF SUSPENDED SOLIDS DISCHARGED FROM DREDGING OPERATIONS

The increasing threat of inorganic suspended solids (SS) to the aquatic habitat has finally caught the attention of water pollution control authorities. Unfortunately, the present knowledge of harm done by the point discharge of silt or sediments from dredging operations is ambiguous. The state of the art presented in the paper shows that adverse effects of thresholds reported varied from 40 mgSS/dm^3 in one case of a salmon fish river to as high as 100 000 mg/dm^3 in case of a lowland river. The existing data tend to support the hypothesis that the damage to adult fish arrives a long time after a permanent damage to the whole food chain is established. Various regulations or recommendations on suspended solids are issued which document the lack of solid scientific basis for evaluating the allowable discharge of spoils. The tests used presently are semi-dynamic at best and, due to the complicated sorption-desorption characteristics of nutrients, detergents and heavy metals are unable to represent the actual wide area-deep water case.

The paper discusses the environmental effects of maintenance (navigation) and aggregate dredging operations and presents results of a field study of a sand and gravel operation with data on environmental effects and effluent treatability.

1. INTRODUCTION

All engineering projects in rivers, estuaries or coastal areas involve a change in the quantity, suspension, distribution or redeposition of sediments. Interest in the evaluation of probable biological effects of suspended loads and deposited sediments has recently been considerably increased. A wide variety of engineering projects, under way or planned, call for a rapid establishment of water quality criteria and standards since up to recent times, the maintenance of navigable channels, cutting of new waterways, dredging for sand and gravel etc., have historically been considered as non-pollutional engineering enterprises. Although the dredging industry is seldom given priority for clean-up of their wastes, the authorities had finally recognized, that these engineering activities may, if uncontrolled, result in serious damage to the biota.

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Survey of the literature [34] shows that little is known about the possible harmful effects of dredging effluents on the biota: the need for establishment of ecologically sound and economically feasible standards is also evident. The standards should be suited to the particular conditions of the river, its natural suspended solids load as well as to the assimilating capacity of the bio-system.

The purpose of this paper is to raise the subject of the increasing presence of suspended solids in the aquatic environment; to define several areas where the quality of aquatic habitat is affected and to describe briefly the detrimental effects of dredging operations. This will be done on the basis of a brief survey of the state of the art and on an example of the author's survey of a dredging operation on the Ohio river.

2. NATURAL SOURCES AND VARIATIONS IN SUSPENDED SOLIDS LOAD

The concentration of suspended sediments in the surface waters is influenced by several factors, such as rainfall, its duration and intensity, soil conditions, topography, geology, type and intensity of vegetation and man's activities in the basin.

Changes in these factors may result directly or indirectly in significant changes in suspended solids concentrations, which sometimes may be very drastic. Sediment concentrations may vary from several mg/dm^3 to several thousand mg/dm^3 in the same river [31, 53]. The combined natural and induced erosion and runoff problems are very serious. As indicated by several authors [25] an annual world sediment yield is 20×10^9 tons, of which 80-85% is contributed by Asia and North America. Average suspended sediment discharge of rivers to oceans is 667 tons/km^2/year in North America; 4165 — Asia; 435 — South America; 313 — Australia; and 245 — Europe. The discharge depends on the type of the river, thus for the Colorado river it is equal to 2 945 tons/km^2/year and to only 754 tons/km^2/year for the lowland Mississippi or to 344×10^6 tons/year.

Various water authorities and organizations are now involved in monitoring the sediment discharge — the methods of US Geological Survey [32, 41] are widely adopted.

Most freely flowing surface waters demonstrate significant day—to–day variability in the suspendedsolids concentrations. The suspended load may also vary with different stretches of a stream, particularly when the bed load is resuspended or deposited due to changes in the hydraulic regime.

MAŃCZAK [29] has studied various polluted and unpolluted rivers to arrive at a generalised equation which contains a sum of terms const/Q and const$\cdot Q^a$: the first denotes flows below the bed stability threshold, while the sum usually applies to flows above the mean low flow (MLF). In a particular case of Odra river at Chałupki, MAŃCZAK found the solids load S (kg/s) versus flow as:

$$S = 129.6Q^{0.94}, \tag{1}$$

where the flow rate Q is in m^3/s.

3. IMPACT OF SUSPENDED SOLIDS ON AQUATIC ENVIRONMENT

The question as to how much silt or suspended matter is deletorious, cannot be precisely delineated. However, detrimental effects of suspended solids load in the ecosystem can be characterized and the importance of each effect outlined.

Silt alters aquatic environments, primarily by screening out light, by changing heat radiation, by blanketing the stream bottom, and by retaining organic material and other substances which create unfavourable conditions for the benthic organisms.

3.1. SEDIMENTATION AND BLANKETING OF THE STREAM BOTTOM

This factor concerns both the organisms living in bottom of the river or other body of water, as well as higher organisms which depend upon those organisms for food. Sediment deposition is primarily damaging fish eggs burried in the bottom. This fact was recognized as early as 1923 when HARRISON published his experiments on the hatching of fish eggs in gravel [24] which yielded the number of hatched eggs decreased proportionally to the decreasing size of the bottom substrate, gravel and sand. Unfortunately, present industrial activies offer a multitude of examples when prolific stream beds have been smothered with soil and clay and washed out as a result of soil scarification or gravel extraction processes. Silt from a gravel washing operation drastically reduced bottom organisms of Cold Creek and the Truckee river, California; over 90% population reductions occurred immediately below the outfall, and reductions of over 75% were noted for more than 15 km downstream [14].

3.2. MECHANICAL ACTION OF SILT

Mechanical or abrasive action is of particular importance to the higher aquatic organism such as mussels and fish [12]. Impairment of the fish gills action may have a multifold effect as the gills are used not only for respiration but for excretion of various harmful products of metabolism. Silt affects also the swimming ability of fish. As pointed out by WILBER [50], excessive amount of silt may directly affect fish and other organisms swimming in water, i.e. to kill them, reduce the rate of growth, decrease their resistance to disease and so on.

The mechanical action of sediments on fish can be measured quantitatively by measurements of oxygen uptake rates in the enclosed body of water.

Lethal action of nuisance material depends to a great extent on the type of particles present. Synergistic effects of high temperatures and low dissolved oxygen levels are also very significant [43]. Studies conducted on several kinds of China clay particles which had already smothered several rivers in Great Britain have revealed that this type of suspension is not directly harmful but the damage is obvious after prolonged period of exposure. It has been indicated that coarser particles may be more harmful than fine ones: this depends also on the hardness of the material [4, 5].

Heavy or irritating concentrations of solids might interfere sufficiently with gill movements to affect circulation in the capillaries and finally the entire circulation system. Also, production of large quantities of mucus in defense to abrasive action may result in tearing or sloughing so that portions of the epithelium are exposed [12].

Some studies indicate a significant resistance of fish to turbidities. In research work conducted by WALLEN observable behavioral reactions caused by turbidity did not develop until concentrations of turbidity approached 20 000 mg/dm^3 and in one species adverse reactions did not appear until turbidities reached 100 000 mg/dm^3 [49]. The turbidity was introduced with montmorillonite clay. Most individuals of all species used endured exposures to more than 100 000 mg/dm^3 for a week or longer. Average fatal turbidity ranged from 38 000 mg/dm^3 (*A. rupestris*) to 222 000 mg/dm^3 (*A. melas*). These data indicate that the direct effect of montmorillonite clay turbidity at the degree found in nature is not lethal for juvenile to adult fishes.

EIFAC (FAO) reports high level of harm at much lower turbidities and recommends standards for suspended matter – not to exceed 400 mg/dm^3, inasmuch as natural turbidities are usually caused by hard particles, and specifies the criteria for stream fisheries [18] as in table. The same table shows also the values set by the Polish Water Law for the three basic water quality classes: I-fit for salmonidae and municipal water supply; II-fit for recreation and fisheries other than salmonidae, III-fit for industrial and agricultural uses.

Table

Classification of water quality according to EIFAC and the Polish Water Law (WL)
Klasyfikacja jakości wody zgodnie z EIFAC i Polskim Prawem Wodnym

Class (WL)	Description (EIFAC)	Suspended solids (mg/dm^3) (WL)	EIFAC
I	optimal	20	25—30
II	good	30	30—85
III	poor	50	85—400
beyond class.	extremely bad	50	400

Reliable as these and other observations may be, the fact remains that little data are available to support any universal answer, i.e. to state whether or not sediment is directly harmful to fish. In most cases indirect damage to fish population through destruction of the food supply, eggs or alevins, or changes in the habitat occur probably long before the adult fish are directly harmed [15].

3.3 DECREASE IN THE DEPTH OF THE EUPHOTIC ZONE

Increasing turbidity reduces the light penetration which, in turn, limits primary productivity by limiting the column of water in which light intensity is sufficient (about 1% of incident light) for the rate of photosynthesis to exceed the respiration rate [42]. The decrease of euphotic or lighted zone has been noted by several authors [6, 9, 10, 51].

Since photosynthetic organisms form the base of the energy or the food chain any significant change in their populations would have a widespread effect on the organisms dependent upon them for food.

CAIRNS points out negative effects on predators that depend on sight to catch their prey and the side effects of resulting over-population [12].

3.4. OXYGEN DEMAND

The concentration of dissolved oxygen (DO) is decreased by the oxygen demand exerted by organic matter adsorbed to the particles of resuspended sediments and by reduction of light penetration which reduces the photosynthetic oxygen production. These depressions in DO content may be quite large, as demonstrated by the 83% reduction in DO after dredging at Arthur Kill [45].

Resuspended sediments increased oxygen demand eightfold in Thames river — from 0.05 g O_2/m^2 — benthic demand — to 0.4 g O_2/m^2 in suspended form [26]. This is usually noted in contaminated water bodies, as sediments represent a history of pollution and when moved exert an immediate oxygen demand. These effects of anaerobic metabolism have been well demonstrated in a recent study at Naragansett Bay [39].

3.5. SORPTION AND RELEASE

The surface of particulate matter may act as a substrate for bacteria and other microorganisms, thus changing the habitat. The adsorption of nutrients is very significant — the term "silt trap for phosphate" has been used by JITTS [27].

SHERK, after a thorough literature perusal, concluded that available evidence tends to support the contention that fertilization, i.e. nutrient release and possible release of toxic materials occur in the water with resuspension of bottom material [42].

Dissolved organic matter content may increase even 100 000 times when adsorbed to very fine inorganic particles, this, however, is the aftereffect of previous pollution incidents.

3.6. PRIMARY PRODUCTION

As noted earlier the quenching of light in the euphotic zone tends to limit this zone to the upper layers, thus reducing the primary productivity.

On the other hand, it has been demonstrated that turbidity in the column of water can indirectly stimulate photosynthesis [33, 42]. In case of an excess of respiration over photosynthesis, inorganic nutrients accumulate and, in turn, stimulate photosynthesis. Several sources report [42] that enhanced productivity, expressed in terms of chlorophyll a, can be attributed to redisposition of dredged spoil; the stimulation is related to the addition of nutrients.

However, while turbid material may not be disastrous in shallow waters it certainly reduces or excludes photosynthesis in deeper waters.

3.7. DENSITY AND TEMPERATURE EFFECTS

Turbid material may alter the rate of temperature change in waters, particularly in the deep rivers and lakes where thermal stratification of the water produces a stratification of the silt load. A warm water will possibly flow over a cold layer, while water containing high concentrations of solids may appear as an underflow during the summer months. ELLIS has pointed out that, except for the very quiet portions, silt material is quite uniformly distributed throughout the waters of rivers even in very deep holes, and in those impoundments where there is no stratification [16].

The formation of density flows has been evidenced in several cases involving high concentrations of suspended solids within the discharged plume. These density plumes depend on a combination of factors, such as type and settleability of the suspension, concentration and method of discharge, thermal and hydraulic regimes, mixing and diffusion conditions.

Such confined density currents are particularly visible if the fine suspended matter has a specific gravity not too much greater than the layer into which it is released. These phenomena have been well documented during the maintenance dredgings in Bellingham Bay, Puget Sound and the Willamette river [37]. In Chesapeake Bay the sediments were carried (in the top 3 m of water) in a plume to a distance of 5 km [8].

4. MAN-MADE SOURCES OF SUSPENDED MATTER IN SURFACE WATERS

Inasmuch as the natural silt erosion and suspended solids loads in rivers have received adequate attention, the literature on man-made sources (i.e. point sources) has been very limited.

There are two basic dredging operations — from the viewpoint of impact on water quality considered separately. Navigation and maintenance dredging involves redeposition of large quantities of sediments, frequently in areas where sediments are containing wastewater sludges. These operations are pursued in ports, harbours and industrialized channels.

Dredging for sand and gravel will be usually distributed in those places where sand contents in the deposits is appreciably high, containing minimum of impurities. The effluent from such dredging, as opposed to that of navigation dredging, contains only small portion of solids and these are usually very fine particles.

4.1. NAVIGATION AND MAINTENANCE DREDGING

This type of dredging is conducted primarily by means of hopper dredges [48, 17]. Other dredges such as dipper dredge, bucket dredges and ladder dredges are also used.

A hopper dredge is essentially a self-propelled ship with suction pipes and pumps working, while the dredge is under way, at slow speed and while the drag heads slide over the sediments to be dredged. After the hoppers have been filled with sediment, the pumps are shut and the dredge itself transports its load to the disposal site. Other methods involve direct redeposition in shallow parts, through a system of extension pipelines or on-shore disposal [30].

4.1.1. ENVIRONMENTAL EFFECTS

Detrimental effects of these activities depend entirely on the quality of sediments dredged. In the Great Lakes, about 12×10^6 m^3/year of material is dredged. The pollutional characteristics of dredged material varied there tremendously between harbours, [48]. Of the 122 of maintained harbours over 40 were found to be seriously polluted. In that area efforts to find alternative disposal methods to the open-lake dumping were quite successful. Land disposal in diked areas proved to be by far the most economical and satisfactory; as various kinds of treatment such as areation, flocculation or burning proved to be too expensive.

Although the actual effects of open-water and deep water disposal have been studied in many locations: in Chespeake Bay [2, 7, 8, 19], Rhode Island Sound, Florida coastal waters [46, 47] Gulf of Mexico and Great Lakes, the effects of this method of disposal remain uncertain. In a comprehensive study on Chesapeake Bay, where 7.5×10^6 m^3 are dredged [2, 8], the discharge of spoil resulted in increased turbidities in an area of 4-5 km^2, while phosphates and nitrogen concentrations increased by factors of 50 and 1 000, respectively — without affecting the phytoplankton. At the same time the benthos was reduced by 65% of the total biomass — its recovery period was almost two years.

Laboratory aquaria have frequently been modified to conduct sediment selectivity tests which gave discriminative answers to the suitability of a given sediment to native species. This benthos viability test is conducted on a particular water from the studied area and given top layers of native sediments should yield adequate results for most engineering purposes [21].

Recent establishment of criteria or recommendations for discharge of dredged material — such as in the Helsinki Convention [36] and by US Environmental Protection Agency [1] has lead to establishment of numerous techniques of which the standard elutriation test is the simplest one. It is based on mixing sediment with the water of the receiver (1:4) and studying the elutriate — a method found valid for COD, chromium, cadmium, TKN, arsenic, nickel and zinc and inadequate for mercury, lead and copper [22]. Other studies question all these methods as only manganese seems to be released, while all other metals tend for immediate readsorption [28] or are simply not released at all.

4.2. SAND AND GRAVEL INDUSTRY

One of the most widely used methods of sand extraction is through the cutter-head and/or suction pipe-pump system such as depicted in figs. 1 and 2. Slurry is transported on the top of a very coarse screen followed by a series of smaller size screens, usually vibrating, the

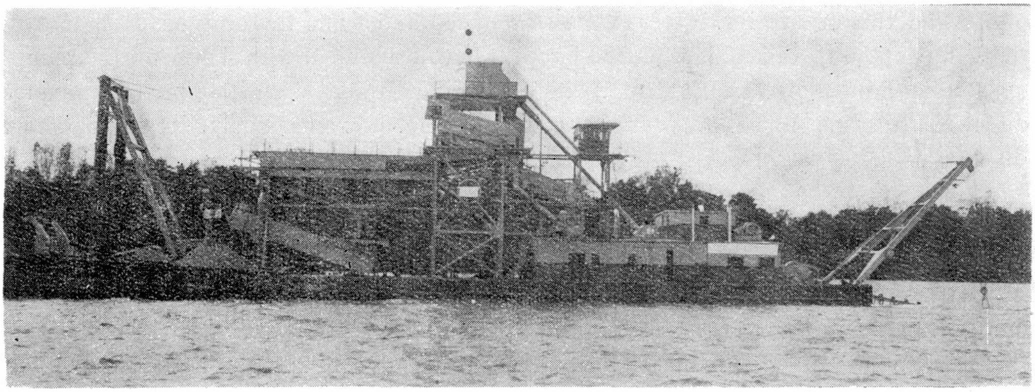

Fig. 1. Typical suction pipe-pump sand and gravel dredging — sorting — milling system

Rys. 1. Typowy system ekstrakcji, sortowania i mielenia frakcji piasku

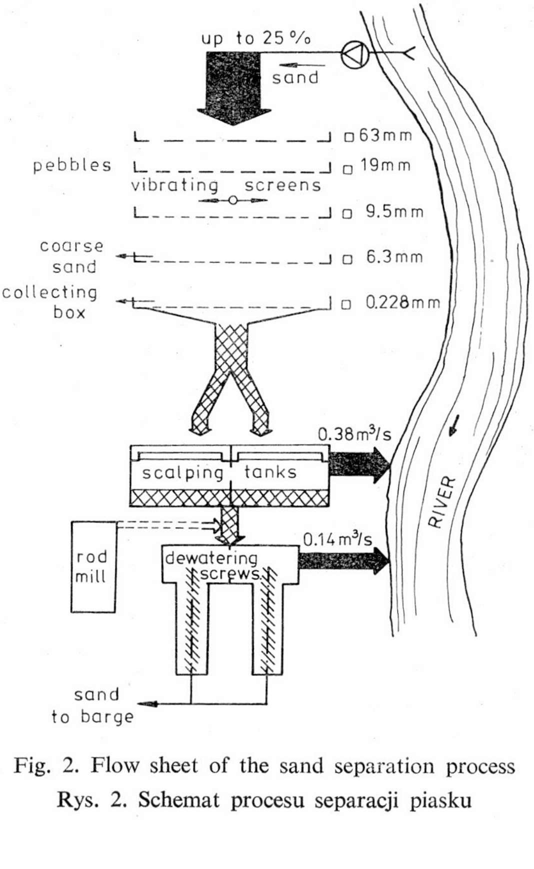

Fig. 2. Flow sheet of the sand separation process

Rys. 2. Schemat procesu separacji piasku size of the openings depends on sand specifications. Finally, the slurry enters rapid (scalping) sedimentation tanks where hydraulic separation of finer particles is achieved. Further separation of fines can be obtained through grinding in rod mills. Effluent contains very fine particles, usually 98% below 200 meshes, the concentrations may vary, according to the location and operation procedures, from 1 000 to 50 000 mg/dm^3 and more.

In some large operations on Potomac river discharged solids contributed an average of 5 kg/s at concentrations up to 47.000 mg/dm^3, to the 100 000 kg/s (45 mg/dm^3) carried by the river. Annual contribution of dredgings is roughly only 7% — this being primarily redistribution rather than a quantitative inflow [19, 38]. Approximately 75% of the particles were within the silt range of settling velocities (0.6-1.9 mm/s). The plume of maximum 150-250 mg/dm^3 was distinguishable some 5-6 km downstream. Proposed solutions included diffusion within the estuary versus confined settling; on-shore or land disposal; flocculation in place and discharge according to the flow intensity.

Dredging operations by three sand and gravel companies on the Allegheny river revealed insignificant increase of turbidities and suspended solids below the dredges [34]. For example in one case no distinguishable effect was found; the increase over ambient below the dredge was 1.5 mg SS/dm^3, 300 m downstream. Yearly averages at Warren revealed 6.6 mg SS/dm^3 above and 32.1 mg SS/dm^3 short distance below the dredge.

Several grab samples of Alabama river water [34] revealed no effect of dredging on dissolved oxygen contents or pH; the highest difference in suspended solids between upstream and downstream samples was 5.4 and 23.5 mg/dm^3, respectively, 150 m from the dredge, downstream.

Limited scale studies on Caney Fork river in Tennessee showed rather random variations of measured parameters, not related to the dredging operations. On the other hand, a very significant contribution of suspended solids due to rain-water runoff and improper land management practices, was noted [13].

Unfortunately, there are many sites where adverse effects were clearly noted. An increase by only 80-100 mg/dm^3 of suspended solids in the South Platte river — below an on-shore gravel operation resulted in 60-85% decrease of fish population below the site [3].

The commonly used species diversity index [SDI] is not always affected, as the species may be affected similarly, as noted by an EPA study, which showed that an increase up to 80 mgSS/dm^3 yielded 60% decrease of macroinvertebrate density and no change in SDI [20]. On the other hand, Cairns has found the change in SDI after modifying its use in a study where much more complex response of fish was found and where two years did not allow full recovery of the fish and macroinvertebrates. The load imposed was only 40 mg SS/dm^3 — seasonally even smaller [11].

4.3. SAND DREDGING — CASE STUDY

The studies were conducted by the author on the Ohio river, close to its confluence with the Mississippi river [34]. Complete on-board sand and gravel production plant was studied, as depicted in fig. 2 and located as in fig. 3. The final effluent was analyzed for organics,

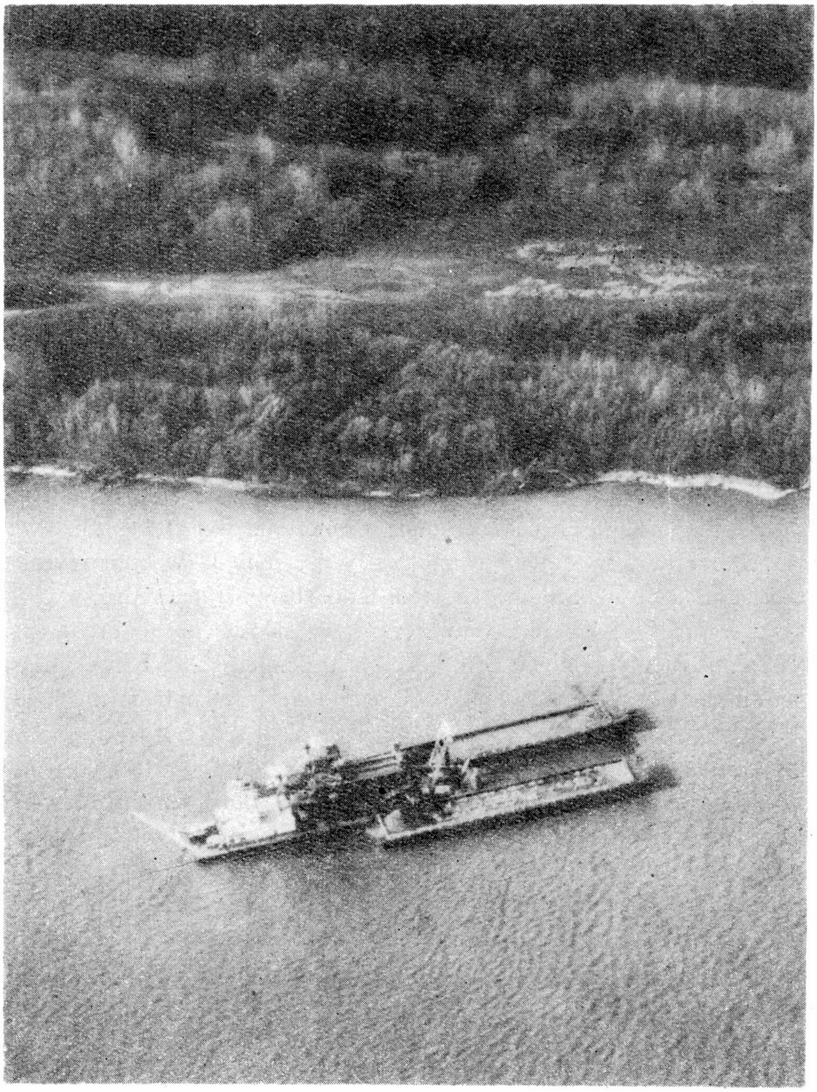

Fig. 3. Dredging and processing plant with two cargo barges located in the Ohio river. (No visible plume was detected beyond 30 m downstream from the discharge)

Rys. 3. Zakład eksploatacji i sortowania piasku z dwoma barkami na rzece Ohio. (Nie stwierdzono wizualnie smugi zawiesin już 30 m poniżej zrzutu)

heavy metals and solids while the river stretch below was subjected to intensive biologica survey for any possible changes in the aquatic biota — both suspended and attached species. Major emphasis was placed on benthic organisms collected by Petersen dredge and onl periphyton (immobilized by means of pralgometers and Hester-Dendy samplers).

The effluent contained usually 1 000-3 000 mg SS/dm^3; during the operation of the rod mill the solids increased to 16 000 mg/dm^3 which amounted to a discharged load of 3.75 t SS/h. Typical distribution of solids in the effluent, determined by means of a sieve and pipette method, is shown in fig. 4. The organics concentration, expressed as COD, BOD and TOC, was negligible due perhaps to the good quality of the river water at this location. Typically, the effluent turbidities ranged from 150-360 JTU, the volatile suspended solids were 120-210 mg/dm^3, COD — 100-180 mg O_2/dm^3, TOC — 1-4 mg C/dm^3, BOD_5 — 9-10 mg O_2/dm^3, and phosphorus — 1.8-2.1 mg PO_4/dm^3. The occurrence of heavy metals (mercury in particular) was found at very low levels — close to the detection limits, however, when multiplied by the effluent volume (0.52 m^3/s) it could yield accountable daily quantities. The question of mercury is, however, the most difficult to assess due to its erratic sorption-desorption behaviour, as noted also by other writers [28, 40].

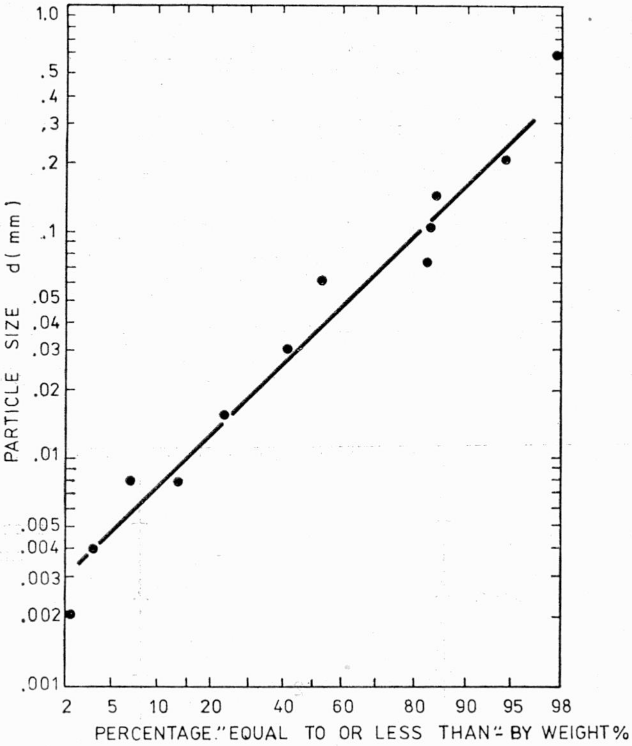

Fig. 4. Particle size distribution using the sieve and pipette method

Rys. 4. Rozkład cząstek piasku sporządzony metodą sitową i pipetową

4.3.1. ENVIRONMENTAL EFFECTS AND EFFLUENT TREATABILITY

The downstream environmental effects were assessed on analysis of data from twenty stabilized sampling points (by using buoys) in five river cross-sections extending some 3 km downstream from the point of discharge. The sampling (encompassing three seasons) revealed almost immediate disapearence of the suspended solids plume (i.e. after 25-40 m downstream). The statistical analysis of the data from downstream cross-sections (variance ratio test) revealed no significant difference in any of the physicochemical parameters measured. The percent solids input to the river, as measured on site, varied from 0.10 to 1.63% — the higher value was for low flow condition and maximum operational capacity. The river carried from 6.6×10^5 to 17×10^6 kg SS/day at low flow and average flow conditions, respectively.

The biological studies have also revealed no significant difference in the pollution sensitive organisms numbers and lack of diversity between the upstream and downstream sampling stations.

The effluent was treated by sedimentation or coagulation or by polyelectrolytes. Treatment was required to arrive at the maximum turbidity of the effluent between 30 and 50 JTU (Jackson Turbidity Units).

The plain sedimentation tests have revealed that hourly retention still yields effluent well above 100 JTU (fig. 5-1). The studies of officiency of various coagulants proved that

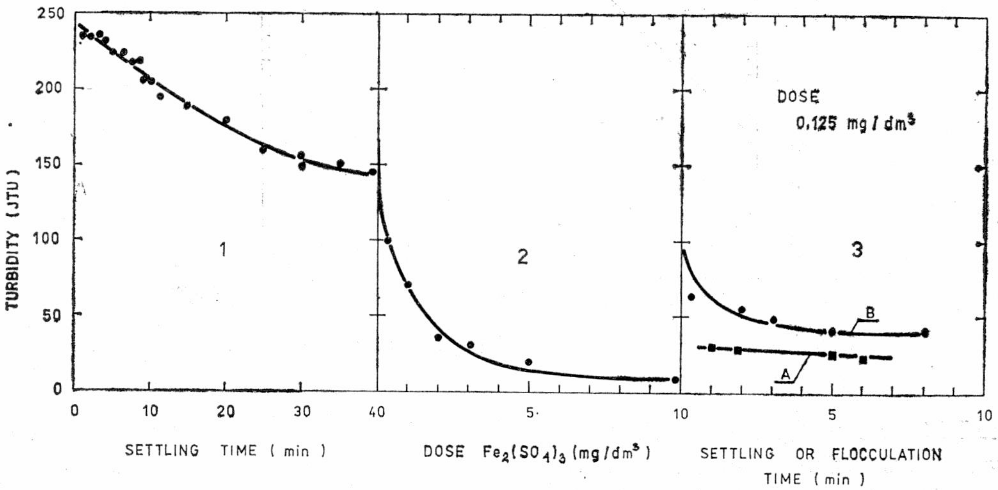

Fig. 5. Treatability studies:

1 — typical settling curve, 2 — results of coagulation with ferrous sulphate, 3 — effects of NOPCOFLOC polymer alone on settling time (A) and on the minimum flocculation time (B)

Rys. 5. Badania nad oczyszczaniem ścieków:

1 — typowa krzywa sedymentacji, 2 — wyniki koagulacji siarczanem żelaza, 3 — wpływ jednej dawki polielektrolitu NOPCOFLOC (dawkowanego bez koagulanta) na czas sedymentacji (A) i na minimalny czas flokulacji (B)

excellent removals could be attained at very low doses, below 5-10 mg/dm^3. Fig. 5-2 presents ferrous sulphate data — a correlation was found between the length of flocculation and settling time and the resulting turbidity.

In order to decrease the time required to complete the treatment to the 30 JTU turbidity threshold, various polyelectrolytes were used (without the primary coagulant). The results, discussed extensively elsewhere [35], have proved that with an optimized dose of 0.125 mg/dm^3 of Nopcofloc adequate treatment is attained at retention times below 20 minutes (fig. 3-5).

It was recommended to conduct this operation in one of the unused sand barges where 0.25-0.4 h retention time could be easiely provided. The dredging company was interested in retaining fines in their product and thus welcomed the possibility of fine particles extraction from effluent.

The above comparison shows that although there is no way of meeting the requirement of a maximum of 25 JCU turbidity difference between wastes and river water, at all conditions, tremendous dilution factor makes the effects negligible; this is particularly evident f a reasonable mixing zone is established — even as short as 50-60 m.

5. SUMMARY AND CONCLUSIONS

The problem of inorganic sediments in streams and seasonal variations of suspended olids load has started with the first river running towards the sea. Unconsciously, gradual ncrease of unplanned and carefree human activities in the drainage basins resulted in arge scale, uncontrolled problem of extensive soil erosion which for certain drainage basins s definitely one of the prime threats to water resources.

As early as in 1936, **Ellis** [11] reported that due to increased erosion silt loads, the o-called "millionth intensity depth for light penetration", a measure of light transmittance roperty of water, decreased in some rivers 15 to 35 times in a rather short period of time; he figure being a conservative estimate, as in some cases the transparency was decreased ver 70 times.

The only confined and controlled source of suspended solids, plainly visible on the ivers and lakes is the fleet of dredges. The much more disastrous effects of such sources f turbidity as highways and bridge construction, unplanned soil management, deep and trip mining, dam construction, logging, soil scarification or rock crushing industry should ot be overlooked. The effect of increasing turbidity in surface waters is multiplied by the ollution resulting from municipal and industrial pollution as well and the ever increasing gricultural non-point sources. Silt and solids producing operations tend to change the atural, adapted through gradual processes, habitat rather rapidly; the degree of harm epends primarily on the background turbidity of the water body. Numerous streams, hich had provided valuable game fish have turned into coarse fish, unproductive water ourses, due to solids content increase.

The resuspension of sediments during dredging is contrary to the self-purification tendncies of the stream, particularly during low flow periods, if only the peril of heavy metals sediments is to be mentioned. The evaluation of damage is, however, very difficult and as successful in very few cases. In Boca Ciega, Florida [47] an estimated value of 1.4 million annually has been reported as a result of filling operation of the bay by hydraulic dredging. Although the example has little in common with sand and gravel operation, it stresses the need for rational cost-benefit analysis. Such analysis must be included in the overall clean-up program involving all sources of pollution in the drainage basin. The problem is immediately aggravated if the river carries settleable organic matter of wastewater origin. Awareness of the possible pollutional effects of the sand and gravel industry operations on stream biota, and the demand for rapid upgrading of quality of industrial effluents discharged to surface waters, call for a much more extensive research that should involve:

treatability studies — including sedimentation, chemical precipitation, with interest for recovery of fine particles,

means and methods of inducing sediment deposition and removal,

improved diffusion of treated effluents versus confined settling; reduction of the visible plume effects,

bleeding retention basins and discharge according to the pattern of high flows occurrence,

diked disposal,

on-shore or on-land disposal,

other economical uses of dredged sediments.

As documented in this paper the problem of introduction or resuspension of inorganic solids needs to be analyzed on a case by case basis. The environmental effects will depend as much on previous history of the water quality of the stream and thus the quality of deposits, as on the present water quality and the adaptability of the downstream biota. The effluents from these confined operations are found very easiely treatable. It should be noted, however, that the dredging point sources may frequently be responsible for only an insignificant portion of the sediment load carried by the river — as most of the load originates in the non-point runoff from agricultural and industrial areas.

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WPŁYW ZRZUTU ZAWIESIN Z POGŁĘBIANIA I WYDOBYWANIA KRUSZYWA NA JAKOŚĆ WÓD

Rosnące zagrożenie środowiska ze strony nieorganicznych zawiesin stało się ostatnio przedmiotem zainteresowania inżynierii ochrony wód. Niestety obecny stan wiedzy na temat szkód wyrządzanych przez punktowe zrzuty zawiesin pochodzących z operacji pogłębiania i wydobywania kruszywa z dna rzek, zatok i kanałów jest niewielki i niejednoznaczny. Przegląd stanu wiedzy przedstawiony w artykule dowodzi, że w jednym przypadku ujemne oddziaływanie (na rzekę łososiowatą) wystąpiło już przy stężeniu 40 mg zawiesin (Z)/dm^3, zaś w przypadku rzeki nizinnej dopiero przy stężeniu 100 000 mg Z/dm^3. Istniejące dane potwierdzają hipotezę, że ujemny wpływ zawiesin na ryby występuje długo po utrwaleniu się uszkodzenia całego łańcucha pokarmowego. Kryteria i zalecenia odnośnie do stężeń zawiesin w wodach świadczą o braku naukowych podstaw do oceny wpływu zrzutu zawiesin podnoszonych z dna akwenu czy cieku. Stosowane testy nie są dynamiczne, a skomplikowany mechanizm sorpcji i desorpcji związków biogennych, detergentów czy metali ciężkich nie pozwala na właściwą prognozę zmian czystości wód odbiornika.

W artykule przedstawiono wpływ operacji pogłębiania oraz wydobywania piasku i żwiru oraz pływającego zakładu produkcji kruszywa na stan czystości wód. Ponadto zreasumowano wykonane badania mechaniczno-chemicznego oczyszczania ścieków z tego zakładu.

DER EINFLUSS VON SCHWEBESTOFFEN AUS DER BAGGERUNG UND KIESGEWINNUNG AUF DIE WASSERGÜTE

Die Verschmutzung von Gewässer mit anorganischen Schwebestoffen steigt in letzter Zeit immer mehr. Der Wissenstand über angerichtete Schäden durch punktartige Anreicherung von Schwebestoffen aus der Baggerung von Fließgewässer, ist sowohl unzureichend wie nicht eindeutig.

Der im Beitrag gegebene Überblick beweist, daß negative Erscheinungen im Fluß mit lachsartigem Fischbestand schon bei 40 mg/dm³ Schwebestoffen beobachtet wurden, in anderen Fall eines Tieflandflußes traten Störungen erst bei 100 000 mg Feststoffe/dm³ auf. Das scheint die Hypothese zu bestätigen, daß der negative Einfluß auf den Fischbestand erst dann eintritt, wenn eine Schädigung der kompletten Nahrungskette zum Vorschein kommt.

Die Kriterien und Empfehlungen betr. der Schwebstoffkonzentrationen im Gewässer zeugen vom Fehlen wissenschaftlicher Grundlagen zur Bewertung des Einflußes der Schwebestoffe die aus dem Flußboden ausgebaggert werden. Das angewandte Testverfahren ist nicht dynamisch und komplizierte Mechanismen der Sorption und der Desorption von Nährstoffen, Detergentien und Schwermetallen gestatten keine Aussage über die zukünftige Wasserqualität im Vorfluter.

Im Beitrag wurde der Einfluß der Baggerung, der Kiesgewinnung, sowie einer Baggerschute mit Kieswäsche auf den Reinheitsgrad des Vorfluters untersucht. Ausserdem wurden Untersuchungsergebnisse der mechanisch-chemischen Reinigung solcher ,,Abwässer" zusammengefasst.

ВЛИЯНИЕ СБРОСА СУСПЕНЗИЙ, ПРОИСХОДЯЩИХ ОТ УГЛУБЛЕНИЯ И ДОБЫЧИ КРОШКИ, НА КАЧЕСТВО ВОД

В последнее время возрастающая опасность загрязнения природной среды со стороны неорганических суспензий стала предметом заинтересованности санитарной техники охраны вод. К сожалению, имеющиеся до сих пор знания на тему вреда, наносимого отдельными пунктами сброса суспензий, происходящими от операции углубления и добычи крошки из дна рек, заливов и каналов, являются незначительными и неоднозначными.

Обзор состояния знаний, приведенный в статье, доказывает, что в одном случае отрицательное воздействие на лососёвую реку наступило уже при концентрации 40 мг суспензии (Z)/дм³, в случае же равнинной реки только при концентрации 100 000 мг Z/дм³.

Существующие данные подтверждают гипотезу, что отрицательное влияние суспензий на рыбы выступает долго после закрепления повреждения всей пищевой цепи. Критерии и рекомендации, относящие к концентрации суспензий в водах, свидетельствуют об отсутствии научных основ для оценки влияния сброса суспензий, поднимаемых из дна акватории или водотока. Применяемые тесты не являются динамическими, а сложный механизм сорбции и десорбции биогенных соединений, детергентов или тяжёлых металлов не даёт возможности правильного прогноза изменений чистоты воды приёмника.

В статье описано влияние операции углубления, добычи песка и гравия, а также плавучевого завода производства крошки на состояние чистоты вод. Кроме того, подведены итоги произведённых исследований механико-химической очистки сточных вод от этого завода.