THE UGLY FACES OF POLLUTION - Part I

By Morris L. Brehmer and Fred C. Biggs

Note: March 14-20 is National Wildlife Week. Its theme this year is "Fight Dirty Water". Five articles have been prepared that define the catagories of water pollution and the role of science and technology in combatting it. Dr. Morris L. Brehmer heads pollution research at the Virginia Institute of Marine Science and Fred C. Biggs is Information Office at the Institute.

Some states have a greater abundance of water than others. Virginia ranks among the leading states in fresh and salt water resources. Both must be considered when dealing with pollution. Most Virginia land drains into rivers that pass down to Chesapeake Bay and out into the Atlantic. Parts of it drain through North Carolina and into the brackish Tarheel sounds. A rather large section across the mountains drains into the Ohio-Mississippi River network and down to the Gulf of Mexico.

Virginian's recognize that much of our state's economy is based on the availability of water. Leaders, both business and governmental, know that the Old Dominion can sustain enormous growths of industry and population because of it. These same leaders, however, are not taking lightly the effect of increased use on our streams. For over two decades the State Water Control Board has carefully assessed damage to rivers by man-made pollutants, and its work has greatly improved water-resources management here. More important, water quality in Virginia rivers has been upgraded.

In addition, the Virginia Institute of Marine Science, through numerous research projects, has provided information that helps in recognizing the ugly faces of pollution in marine waters: the many forms it takes and the existing and potential sources of it. As better definitions of pollution result from this effort, greater understanding is achieved, and guidelines become apparent for the planners of our tomorrow.

WHAT IS DIRTY WATER?

Dirty water is polluted water. Pollution may come from a number of sources, both natural and man-made. It may be loosely defined as the introduction of any material that destroys the utility of water.

Water pollutants may be listed in five separate categories: 1) Non-toxic materials, 2) toxic materials, 3) oxygen-removing wastes, 4) over-enrichment, and 5) minor wastes. The first of these is considered here. The others will be discussed in succeeding articles.

NON-TOXIC POLLUTANTS

Inorganic wastes include silts, clays, dredge spoil, mine washings and certain types of industrial wastes. Most are the products of erosion. These materials do not remove oxygen from water. They are non-poisonous.

These wastes do have noxious effects upon the aquatic environment. They destroy marine animals by changing bottom types, clogging the gills of some organisms and smothering bottom organisms.

They reduce the food supply in water by limiting the depth of sunlight penetration, therefore, limiting the depth at which green plants can grow. Young fish are destroyed. Larger fish formerly attracted to a stream by certain available foods migrate elsewhere. Seafood production is affected.

Inorganic waste damages the use of water for recreation by reducing its esthetic characteristics. A sandy beach may be covered by thick muck deposits resulting from siltation. Shoreline property is considered less valuable when sandy beaches become muddy.

Before water can be used in homes and manufacturing, industries and municipalities must spend large sums to pre-treat water for the removal of inorganic materials. Also, increasing dredging costs are necessary to keep open shipping channels that are clogged by these wastes.

Silts and clays tend to remain suspended in the water as it flows downriver until it reaches the point where the river becomes brackish or salty. This is in the tidal estuarine portion. Salt water has different characteristics from fresh water. One is that it causes silts and clays to settle out and become loosely deposited in the form of shoals within the river, along its banks or in its channels.

Storms and other phenomena that stir up the water cause constant shifting of these deposits. A shipping channel redredged to proper depth today may be refilled in two weeks in the aftermath of a violent stroke of nature. Such deposits are always in the way, a permanent fixture more or less, each to be dealt with perhaps time and time again.

What is the main source of silts, clays and other suspended inorganic wastes? The answer lies mainly in one word: erosion. We have had erosion since prehistoric times when the mountains were uplifted. But erosion is heavily increased by man's activities.

On well-protected forestland the average soil loss is 20 tons per square mile per year. Cropland loses about 600 tons per square mile per year. In areas undergoing urban development, the loss may go up as high as 50,000 tons per year.

This soil loss from land is received by streams. Although no data are available for the James River, we know that this stream drains 10,000 square miles of Virginia lands. If all of this land were forested, the soil loss to the estuary James would be 200,000 tons per year. Considering other sources of erosion 2,000,000 tons per year would be a fair estimate of what actually occurs. One study shows that over 2.5 million tons of sediment, the product of soil erosion, reach Washington via the Potomac each year, and most of that amount is deposited in the river's tidal estuary in and below the city.

Erosion silt is deposited in the transition zone of estuaries between fresh and salt water, which is an extremely important area for the development of young croakers, trout, flounder, menhaden and other fish. Many are killed outright while others are forced out of the nursery habitat.

Projects in the estuary, such as dredging and spoil disposal, also bring damage to marine life by smothering and changing bottom types. This is usually localized phenomena in which destruction may be complete in the immediate area but conditions are limited to a relatively small area.

Recent studies show that our state's population is rapidly increasing, and it is urbanizing. As this occurs industrial, municipal and recreational pressures on our water supply also increases. Were these pressures to increase without proper management, the ability of our streams to absorb them would diminish.

WHAT CAN BE DONE?

Erosion can only be controlled by management of an entire watershed. Without this the effective life of a city water supply reservoir may be as short as 20 years. For this and other reasons many cities attempt to gain control of reservoir watershed areas in order to control urbanization and other erosion-inducing practices within the watershed. The water's clarity can then be maintained, reducing silt-removing costs when the water is pre-treated.

An elaborate plan has been prepared by the U.S. Army Corps of Engineers for development of the Potomac River watershed in order to provide the future water needs of Washington, D.C. and its surrounding urban complex. The capital city is expected to contain over 5 million people by 2,000 A.D.

State and Federal agricultural agencies constantly urge farmers to follow soil conservation practices. Many acres of marginal lands that were tilled during World War II have reverted to forest production. The soil of cultivated rolling ground is partially protected by contour farming and grass.

Unfortunately we continue to see large areas of urbanization projects laid bare by earth moving equipment and allowed to erode for months before development is started. This practice is not only costly to the developer, but it contributes immensely to the degradation of streams. In such cases, anti-erosion techniques during construction should be practiced.

Dredging and spoil disposal programs cause considerable concern to those familiar with the water. All bottom-dwelling sea life is destroyed in the area dredged, and the animals repopulating the zone may differ from the original ones if a different bottom material is exposed. Also, the animal populations of adjacent areas are changed if large quantities of sediments are disturbed and temporarily placed in suspension.

Many problems are encountered when dredging and dredge-spoil disposal programs are planned. Engineers, seeking an economical method of preventing sediment from washing back into the dredged channel, dispose of the material in areas remote from the channel. Aquatic scientists, aware of the biological destruction resulting from ill-advised spoil disposal, assist in the location of disposal locations in order to minimize the harm to marine life. Continuous cooperation between the two fields will assure maintenance of the water as a multi-purpose resource.

SUMMARY

The fact remains that when erosion occurs, everyone loses: nobody gains. Erosion is costly to the farmer and to the land developer who may need to replace lost soil. Municipal and industrial water users must go to great expense to pretreat water for removal of silt. Shoals hamper shipping and boating, and channels must be periodically redredged, causing considerable expenditures. Marine life is destroyed. The recreational and esthetic virtues of streams and shores are constantly changed, and expensive waterfront properties lose value.

Pollution is indeed the number one enemy of our natural waters. When it occurs, all of us lose something of great value. It therefore follows that all of us can benefit if each of us will join the crusade to keep our waters clean.

FIGHT DIRTY WATER!

THE UGLY FACES OF POLLUTION

By Morris L. Brehmer and Fred C. Biggs

Note: This article will discuss lethal materials that reach our streams and cause large scale damage. Yesterday, we discussed the effects of non-toxic inorganic wastes, mainly erosion, on water. We will continue to discuss the ugly faces of water pollution in this and three succeeding articles this week.

PART II: TOXIC WASTES

Toxic wastes get into our rivers and embayments either directly or indirectly. There are laws in every state of the Union that prohibit the introduction of lethal chemicals into streams as a method of disposal. The sinister fact remains, however, that whole rivers are poisoned not infrequently, and this results in a serious degradation of water quality.

Conservationists and lawmakers alike are faced with the problems of recognizing and defining chemicals which are toxic, and what concentration they must be to harm marine life. A chemical that has no direct noxious effect on a selected marine animal may affect something in its food chain, or it may bring about a change in the animals reproduction capability causing unsuccessful spawning or deformed young. These hidden effects of toxic wastes are difficult to measure, and they present mammoth problems to aquatic biologists.

Marine Scientists throughout the country have embarked on a long-range program to carefully define pollution. Without this, the legal machinery of every state will have one hand tied in efforts to prevent toxic waste pollution.

WHAT ARE THE EFFECTS OF TOXIC WASTES?

Toxic materials destroy wildlife on land and aquatic life in water. They do this by one of three ways: by acute lethal action, by chronic disorder, or by indirect action.

Acute toxicity is easily detected and the source can be promptly determined. Chronic toxicity alters an organism metabolism or life processes so that it is no longer the same. In many cases when the toxic substances does not kill outright, it may weaken species important to commercial or sport fishermen. A fish so weakened quickly becomes suseptible to disease and parasites. It is often difficult to trace chronic levels of poisons to their source.

Indirect effects occur when a chemical destroys the food, tiny plants or animals that are fed on by larger species, resulting in loss of the latter either through starvation or migration. Important commercial and sport fishing species often are affected in this way.

WHAT ARE THE SOURCES OF TOXIC WASTES?

There are two main sources of toxic wastes: industry and agriculture. With the web of streams that characterize the lay of the land in Virginia, it is virtually impossible to find an area that is not drained into one of the large rivers. Since rivers flow toward the sea, all life downstream lies in the path of any relatively stable toxic materials that are released into the stream and not degraded. Therefore, wherever stable poisonous chemicals are dumped on Virginia soil or water, they are funneled into rivers.

Industrial wastes are chemicals used in processing and manufacturing. Some of those that are toxic may consist of simple inorganic compounds such as zinc, copper or the cyanides. Others may be complex organic materials that are the bi-products of a chemical plant.

Agricultural chemicals are a relatively new factor in stream degradation. Over a billion pounds of pesticides are applied to cultivated and forest lands in the U.S. each year. Some of these are among the most poisonous chemicals ever developed by science and technology.

Of this quantity a part is broken down and rendered harmless by sunlight and bacterial action. Another part is retained in the soil, and a third part is washed into the stream system.

Some of these pesticides are extremely poisonous to aquatic animals. For example, less than 1/2 drop of the insecticide recently implicated in the Mississippi River fish kills will make the entire water content of a railroad tank car acutely toxic to fish.

Although pesticides are necessary in producing foods, unfortunately they have been grossly misused. Some which remain poisonous for ten years or more are used in applications where an effective life of 10 days would suffice. These long-lived pesticides build up in the soil and present a long-term threat to fish, fowl and man. They also over-kill, thereby destroying beneficial insect forms.

WHAT CAN BE DONE?

Many things can be, and are being, done to relieve our streams from the poisons that can so easily destroy their utility. Through wise planning and sound resource management, the conflict of interests between agricultural and industrial users of a stream on one hand and those maintaining water quality in the stream on the other generally does not exist. A broad program of educating the public on the effects of stream degradation has been effective. Moreover, industrial leaders are aware of their employees.

Most industries have installed expensive waste treatment facilities that remove both inorganic and complex organic compounds from their plant effluent. Biological treatment of industrial wastes has been found effective where chemical treatment alone will not suffice. For example, strains of bacteria have been developed that are capable of breaking down carbolic acid, a substance widely used as a disinfectant. Other highly poisonous industrial wastes can likewise be broken down to non-poisonous substances by cultured bacterial populations. Most new industries use the techniques developed by sanitary scientists to prevent gross destruction to the receiving stream.

Problems may arise where over-industrialization of an area results in a concentration of waste exceeding the capacity of a body of water to assimilate it. This can only be prevented by joint planning of factory locations by leaders in government and industry.

Regulations and educational programs are also encouraging the use of short-lived pesticides. Long-lived pesticides do have a place in our society, such as in termite control, but environmental science agencies are aware of the potential problems arising from unqualified use of these deadly chemicals, and they are striving to limit wide applications of them over a watershed area.

Everyone can join in this phase of the fight against dirty water. Home owners and gardeners can protect property, pets, family and their vested interests in Virginia's marine resources by carefully following the directions listed on all pesticide containers. Also they should carefully select the proper chemical to do the job at hand.

The toxic constituents of industrial wastes can easily be controlled since they are introduced into a stream at a point source, where quality control is possible and the efficacy of the treatment processes can be monitored constantly. On the other hand, pesticides may be introduced unseen through any ditch or creek. Monitoring for misuse of these chemicals then becomes a monumental and costly task. Many people therefore share the responsibility for controlling pesticide pollution.

Water that poisons fish and other aquatic forms may present health hazards to human consumers. Such contaminants either directly or indirectly damage the water for all uses of it, whether for city, industry, recreation or commerce. Virginia's growing population and its expanding economy needs cleam water.

FIGHT DIRTY WATER!

THE UGLY FACES OF POLLUTION

By Morris L. Brehmer and Fred C. Biggs

Note: Previous articles in this series have covered non-poisonous and poisonous materials that destroy water quality, This one tells of the effects of municipal and industrial organic wastes on a receiving stream, and it discloses modern sanitation methods of eliminating those effects.

PART III: OXYGEN-REMOVING WASTES

Oxygen is a vital ingredient of our atmosphere. Without it, terrestrial animals, including people, could not live. The same is true of water,for without dissolved oxygen, aquatic animals die.

A prime example of this is witnessed when small fish expire in an aquarium or fishbowl. If one dies; other animals in the container are jeopardized unless the dead one is soon removed. The dead animal becomes a form of organic waste, and bacteria rapidly multiply in the container to attack it. A sudden bloom of bacteria, which are oxygen-requiring organisms quickly reduces the oxygen supply of the water, causing death to the other animals. In the process, gaseous compounds including hydrogen sulfide are manufactured, and these produce a putrid stench. This also occurs when food is left to rot in an aquarium, a result of over-feeding pet fish.

Any organic waste dumped into a stream destroys valuable animal life in it by simply removing the oxygen. There are other intolerable conditions created, but none are quite so noxious as oxygen-loss. Every city or factory that releases untreated animal or plant wastes into a river creates such conditions.

When this country was inhabited only by Indians, and through ensuing decades after settlement small communities could discharge wastes into the water without producing nuisance conditions. Although these wastes had high oxygen demands, the dilution factor was great enough so that the stream quality was not significantly altered.

As cities grew and the volume of wastes increased, the streams could no longer absorb such materials without producing putrid conditions. The direct release of such wastes into the water not only killed animal life, but it also presented public health hazards.

As other new cities developed along the water course, quite frequently the stream did not have time to recover before re-use of the water was necessary to supply the downstream city.

These factors, along with a development of higher living standards and the general train of thinking, brought about the development of waste treatment plants and the science of sanitation.

SEWAGE TREATMENT: NATURE vs. TECHNOLOGY

Natural

When untreated sewage enters a natural stream, the larger, heavier particles immediately begin to settle out, forming a sludge bank. This decomposes, robbing the water of dissolved oxygen and giving off marsh-gas bubbles and the rotten-eggs oder of hydrogen sulfide. The particles that do not settle are broken down by chemical and bacterial action which also utilizes oxygen derived from the water.

The complete breakdown of these wastes, when left to nature, depends mainly upon water temperature and the amount of oxygen present. If the dilution factor is too low, animal life in a whole section of the river may be killed off due to low oxygen conditions.

Fishkills also result when a sudden rainstorm washes out the sludge banks releasing poison gases to the water and using up oxygen. This occurred last summer when a drought in Virginia was temporarily broken by hard rains. Numerous streams below cities that had inadequate treatment systems suddenly were filled with dead fish and the air reeked with the stench of their disintegration.

A natural stream receiving sewage is then characterized by three zones: a zone of sedimentation where the solids are deposited, a zone of active decomposition where unstable organic matter reacts with oxygen, and a zone of recovery where the stream is regaining its normal characteristics.

Sanitary Technology

Sewage treatment plants utilize the physical, chemical and biological reactions that occur in a natural stream, but instead of requiring 10-20 miles of stream, this is compressed into a series of tanks, filters and digesters.

When raw sewage enters a modern treatment plant, it first enters a primary settling tank where solids are allowed to deposit on the bottom. The solids are then pumped into digesters and converted into a compost-like material. In some areas, this end product is used as a soil builder and conditioner. It has an earthy odor, and it is high in nitrogen, phosphorus and potassium. At this point it compares with horse manure as a fertilizer, and in some areas it can be purchased for use in lawn development.

The water containing fine particles and dissolved organic material is piped to another tank where large amounts of air are bubbled through it from below, thus mixing and providing oxygen for stabilization.

The final step involves a second settling basin in which most remaining particles are removed. The liquid may then be subjected to chlorination to reduce bacterial populations. Afterwards it can be released onto the stream with minimum damage.

The complete sewage treatment process requires only a few acres per hundred thousand population. Other types of treatment facilities may be as simple as waste stabilization ponds or a type utilizing the large round filters with the familiar rotating distribution arms.

WHAT CAN BE DONE?

All types of sewage treatment projects, when properly operated, minimize damage to the receiving stream. Unfortunately, completely untreated wastes from approximately 12 million people in the United States are being discharged into streams; wastes from another 18 1/2 million are being released only partially treated. This situation can only be remedied through local effort and the allocation of funds to construct and operate treatment facilities.

The Federal government is making funds available to communities that have difficulty in financing sewage treatment projects. Eight hundred million dollars annually are committed to build waste water treatment facilities in the United States for the next ten years. The Public Health Service estimated this level of spending to be necessary to meet 1973 needs. The 10-year total of $8 billion consists of $2.2 billion for immediate needs and the remainder for this expected to arise from obsolescence and population growth.

One might say that this is a lot of money going down the river. Actually it is an investment in rivers all across our nation some of them in Virginia. When we invest funds of that magnitude, we expect value received. Those values cascade upon us in the form of dependable water quality for home use in cities across the country; in the form of a day's fun fishing, boating, sailing, swimming and sunning somewhere along the 2,000-plus square miles of open waters within Virginia borders; in the form of excellent quality seafoods harvested in Virginia and brought to our tables at relatively low costs; and in the form of dollars saved to treat water for urban and factory uses...savings that are passed on to ordinary citizens who must pay the water bill and buy the products of industry.

There is an old axiom that "the solution to pollution is dilution". This is clearly refuted, both by modern sanitary science and by the fact that our population rapidly approaches the 200 million mark, while our streams do not grow in size or number.

In defense of the axiom, one might say that a city located directly on the sea-coast would have the dilution capacity of an entire ocean for raw waste disposal. Were this true, a large metropolis of 2 3/4 million population located on the California coast would not have constructed one of the finest and most modern waste-treatment facilities developed by sanitary science to fully treat 265 million gallons of effluent each day. Unfortunately, near-shore waters can be polluted before effective dilution occurs despite the millions of gallons in the sea.

Across Virginia and across the nation, the fight to keep our waters clean is real and pressing, and it must enlist the support and effort of every citizen if it is to reach a successful conclusion. FIGHT DIRTY WATER!

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NOTE: Previous articles in this series have mentioned three types of stream-destroying wastes: non-poisonous wastes, poisonous ones and those that remove oxygen from the water. This article deals with over-enrichment, also called artificial enrichment and secondary pollution. A concluding one tomorrow will deal with several minor pollutants encountered perhaps infrequently and in special situations.

PART IV. OVER-ENRICHMENT

Ironically, over-enrichment is augmented by man's efforts to abate one of the major sources of water pollution: sewage. Elaborate and costly sewage treatment systems have been devised by sanitary scientists to remove oxygen-consuming substances from streams below large cities, but in so doing, another problem of equal magnitude is sometimes created. Appearance of this secondary problem is another of the ugly faces of pollution.

As sewage wastes are treated to satisfy high oxygen demands before release into a stream, the wastes are converted into basic chemical components. These are harmless compounds within themselves, but unfortunately with a high fertilizing value. Discarding them into the water therefore fertilizes it, supporting plant life in the aquatic environment. Normally the increase in plants provides more food for marine animals.

Over-enrichment results when the receiving stream is fertilized excessively by effluent from a sewage treatment plant that serves a large concentration of people. It may also be called artificial enrichment of the water since the fertilizing action is something other than natural.

Over-richment has the effect of supporting too many plants in a stream. Other factors necessary for plant growth, especially sunlight, may not be available in sufficient quantities to sustain the rapid bloom of aquatic plants caused by over-richment. Although these green plants produce oxygen during the day, they use it at night when sunlight disappears. Very dense populations may use up all of the water's dissolved oxygen before morning. Some of the plants are continually dying and decaying, and the rotting material also requires oxygen. Removal of oxygen from the water will either kill animals directly or weaken them so that they become susceptible to diseases and parasites.

Basically, fertilizer is composed of nutrients that are necessary for plant growth. In nature nutrients are constantly recycled in the soil or water by decaying vegetation and animals. In agriculture this is usually insufficient, and nutrients are spread on cropland in the form of commercially produced fertilizers. They enrich the soil and fortify it for the production of new vegetation. They do the same in water.

Aquatic plants, like their terrestrial counterparts, require carbon dioxide, water, nitrogen, phosphorus and potassium compounds, trace elements and sunlight in order to grow and reproduce. The limiting factor that governs the maximum growth rate of aquatic plants is available sunlight. When their density reaches a certain level, only those cells in the upper few inches of water receive an adequate level of light for normal growth and reproduction.

In deep bodies of water the plants primarily are free-floating microscopic forms called phytoplankton. The dry weight of these plants present in an estuarine system is normally a small fraction of an ounce per gallon of water. This weight can be doubled or possibly even tripled without producing aquatic nuisance conditions.

The miscroscopic plants serve as food for plankton-feeding fish (such as menhaden and the young of many species), filter-feeding shellfish (such as oysters and clams), and a host of other invertebrate animals.

The addition of small quantities of nutrients will produce a moderate increase in the phytoplankton population and theoretically increase the production of plankton-feeders. Animals that feed on the plankton-feeders (such as rockfish or bluefish) will also theoretically increase.

As a result of sanitary treatment, raw sewage is reduced to nitrogen, phosphorus and potassium compounds. These are the three basic chemicals of all commercial fertilizers. For example, a bag of 5-10-5 fertilizer contains 5 percent available nitrogen, 10 percent available phosphorus and 5 percent available potassium.

If the receiving stream cannot provide adequate dilution of the nutrients, the plant population will be stimulated to grow so much that nuisance conditions exist. Tidal streams and estuaries are especially vulnerable to this type of degradation since oscillating tidal currents concentrate the nutrients to levels of two or three times that produced in an inland stream where water flows in one direction.

Marginal conditions also may become critical if the nutrients are introduced into fresh-water portions of a tidal system to become incorporated into fresh-water algae and be carried downstream. Because fresh-water algae cannot tolerate saltwater a die-off zone is created in the transition area, oxygen demand becomes very high, and serious pollution results.

Perhaps a classic illustration of artificial enrichment exists on the Potomac River below our nation's capitol. Approximately 200-million gallons of treated effluent is discharged each day into the tidal Potomac through Washington, D. C. outfalls. By calculation we find that the daily nutrient contribution is 22,700 pounds of phosphorus and 68,100 pounds of nitrogen. The annual enrichment is approximately 8,300,000 pounds of phosphorus and 24,700,000 pounds of nitrogen. This quantity of nutrients represents approximately 45,000 tons of commercially produced 30-10-? fertilizer.

Observations made along the tidal Potomac below Washington during the past two summers indicate that the river cannot assimilate this quantity of nutrients without the production of algae blooms, aquatic nuisance conditions and environmental stress on the higher levels of aquatic life. Algal populations were found in concentrations of more than ten times that normally found in tidal systems, and dissolved oxygen values were often deficient - sometimes approaching zero. One result was that the utility of the water for swimming and water-skiing was reduced by the algal concentration and surface mats. Aquatic nuisance conditions were also observed on the James River but not of the magnitude found on the Potomac.

Unfortunately, people and algae have one thing in common: they both like sunny conditions. This results in the heaviest recreational pressure during the months when algal densities are highest and the esthetic value of the water is at its lowest.

To compound the over-enrichment problem, lowest stream flows are usually encountered during the summer months resulting in lower rates of dilution and higher levels of enrichment. During the low stream-flow period of the summer of 1963, the level of phosphorus enrichment in one of our tidal rivers was calculated to be 10,000 percent and the level of nitrogen enrichment was 1500 percent.

Sanitary scientists are concerned about the effects of artificial enrichment in the entire Chesapeake Bay system. For example, can the upper half of the Bay assimilate the nutrients from the wastes of 5 million people, approximately 120,000 tons of fertilizer equivalent per year, without producing stress conditions for fish and other animals?

WHAT CAN BE DONE?

The problem associated with over-enrichment is simple to define: the receiving stream is so fertile that green plants become obnoxious to those interested in water sports and fishing; the water is not usable in homes since the plants produce tastes and odors, and water treatment is expensive since the plants clog filters; and animal life may be affected by poisonous plant products or low oxygen conditions.

Solutions to the problem are simply described, although implementing them is complex and difficult. There are three primary solutions:

1. A method for recovering nutrients from treated sewage and re-using them must be developed. This would prevent over-fertilization of the stream. At present no economical method is available. This is due to the cost of concentrating the nutrients as compared with present costs of manufacturing commercial fertilizer. Treated sewage contains about 15 pounds available phosphorus and 45 pounds available nitrogen per million pounds of liquid. A city with 2 million people produces nearly 2 billion pounds of treated sewage daily.

2. The treated liquids may be piped to a larger body of water where the dilution will be great enough to prevent over-fertilization. For example, the Hampton Roads area is using this procedure to eliminate secondary pollution in small tributaries and inlets. This course of action is more expensive and difficult for inland cities.

3. The summer dilution rate can be increased by releasing water from reservoirs located upstream. This low-flow augmentation requires the construction of dams and the flooding of land to create reservoirs. Spring run-off water is stored for later release during dry summer periods in order to provide the extra dilution.

The three solutions to the problem require planning before being employed to prevent secondary pollution. An economical method for the first theoretical solution needs technological development. Since phosphorus compounds are valued at 8¢ a pound and nitrogen compounds at 10¢ a pound, income from the sale of recovered waste treatment components might eventually show a profit. The latter two methods are capable of producing significant changes in the salt-water part of estuaries or in the receiving stream. These proposals must be studied very carefully before implementation.

Over-richment resulting from sewage treatment is indeed a modern problem. The next step is to find a feasible solution, and this involves costly research programs. Federal and state governments also recognize this problem, and they are funding research projects in this area of science. But such programs that require expenditures and work need more than the recognition of government: they need the understanding and support of every citizen that is interested in keeping our waters clear and blue...not soupy and slimy green. FIGHT DIRTY WATER!

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NOTE: This is the final article of a five-part series. The others have dealt with non-poisonous, poisonous, oxygen-removing and over-enriching wastes. This one deals with types of wastes not otherwise classified. They are also characterized as those encountered infrequently and arising from special situations.

PART V. OTHER POLLUTANTS

Several other by-products of man's activities may be classified as minor wastes. They are "minor" only in the sense that they have not grown to the mammoth proportions of others.

Minor wastes include tainting wastes, thermal (heat) wastes and radioactive wastes. None may be considered a cause of serious problems in the waters of Virginia today, but each one bears a separate threat, and it is safe to assume that each can become a serious problem unless care and planning attenuate the factors that might cause its increase. In the case of radioactive wastes, the threat could materialize within hours. Therefore these final three lurch among the ugly faces of pollution.

Wastes That Taint Seafood Products

Objectionable flavors in seafood products may originate from certain phases of commerce or industry. "Harbor taste" is a familiar flavor found in fish taken from areas crowded with heavy shipping activity. Small discharges of bilgewater, ballast water, oil and petroleum products from a concentration of ships in harbor areas produce conditions that alter the savory qualities of seafood.

These wastes do not usually produce death in plants or animals, but they do sufficiently taint the flesh of fish to the extent that it can be readily detected by human consumers. The flavor can become very noticeable in certain species, notably shad and rockfish, and many Virginia seafood lovers claim the ability to distinguish between those caught in a harbor area and others taken from an upriver location.

In smaller bodies of water such as a lake or pond, fish flesh can also be tainted by excessive outboard boating activity.

Chemical combination within the stream is another source of tainting waste. For example, two industries located several miles apart may each release a waste that does not cause taste and odor problems, but when these wastes combine, a chemical reaction may occur forming a substance that produces highly objectionable flavors. Regardless of the source, these off-flavors frequently can be reduced in part by skinning the fish, since the taint seems to be associated with a layer of mucus covering the fish.

These are examples of ways in which water quality may be altered without destroying its utility, although the effect created is highly undesirable.

Thermal (heat) Wastes

Heated water effluents (thermal wastes) are introduced by industries using either fresh or salt water for cooling purposes. Quantities discharged back into the river at an elevated temperature may be as high as several million gallons per minute.

Experiments conducted at the Virginia Institute of Marine Science indicate that aquatic plants may be damaged by thermal wastes during summer months when the water temperature is normally high. Since one million gallons per minute indicates an amount that would cover an entire football field with three feet of water, continuous release of this quanitity every minute represents a significant threat to food production in the receiving stream.

If the stream is narrow, this hot water may establish a barrier across the stream that blocks fish migration just as effectively as an earthen or concrete dam. In an inland fresh-water stream a stretch of water unsuitable for plant and animal life does not significantly affect the area upstream nor the area downstream where the rivers recovers. In a salt water estuary, however, a similar heat barrier would affect those species of fish that spawn in the ocean, and whose young migrate the length of the estuary to use the low-salinity upstream areas as nursery waters. It would also affect those species that migrate up to fresh-water to spawn. Likewise, the young of clams and oysters travel many miles up and down the estuary before settling to the bottom to develop.

Therefore, the location of industries that release hot water must involve cooperative planning by manufacturers and sanitary scientists in order to minimize or eliminate potential damage.

Radioactive Wastes

State and Federal agencies strictly regulate the purposeful release of radioactive wastes into natural waters. No damage will occur if the set regulations are followed, and no known unauthorized releases have been made to date.

Marine scientists are studying conditions that might be brought about by accidential release of radioactive materials into an estuary. Although such an accident is highly improbable, owing to our advanced state of reactor technology, the ultimate fate of radionuclides in aquatic systems must be understood. Projects are underway at most marine research stations to provide this understanding.

Summary

The many forms and shapes of pollution as they exist today are no mystery. Yet they exist in important streams across the nation in spite of the availability of knowledge and technology that can eliminate this bane of our civilization. The mechanizations of modern society, the rapid technical advances of our age, and the bulging population centers of our nation have added considerably to the list of stream pollutants in recent years. No one can predict a time when sanitary scientists can relax their vigilance in detecting new pollutants from any source.

The future of the United States is filled with hopes for continued economic growth and gains in standards of living. Materialization of the "American Dream" dictates that each resource that contributes to this ambition should be treasured and nurtured. No resource is more important than our network of natural streams and tidal inlets: the arteries and veins of the country.

Scientists are faced with problems that threaten destruction of many formerly beautiful and clean streams. The Ecology-Pollution Department of the Virginia Institute of Marine Science has completed or is conducting research on dredging and dredge-spoil disposal, thermal effluent, over-enrichment, toxic materials and radioactive wastes. The Institute is joined by other marine research agencies throughout the country in similar projects that answer the call to battle pollution. Publication in special scientific reports or appropriate scientific journals of information gained from these research efforts makes it available to planning, regulatory and industrial agencies.

Professional aid is always available to groups planning developments that in some way affect or are affected by a nearby stream. In Virginia the State Water Control Board, the Department of Health, the Institute of Marine Science and various Federal agencies are on hand to give assistance.

President Johnson has taken a personal interest in rehabilitating the Potomac River. He obviously intends to make it not only clean and inviting to recreationalists, but he wishes to restore its natural beauty and preserve its finest qualities. One day this river that passes through our nations's capital will perhaps become a model of the finest aquatic virtues that should be displayed by every river in America.

Dr. William J. Hargis, Jr., Director of the Virginia Institute of Marine Science has penned the final note to this series of articles as follows:

"Unfortunately many communities and industries are not adequately treating their wastes even though techniques for doing so are available.

"In most instances we do not know enough about the physiology of aquatic organisms and their environmental requirements to be able to recognize damage. Without this information, adequate and realistic water quality standards are extremely difficult to establish. It is easy to recognize gross damage from contamination: the water is putrid and plants and animals die. It is not easy to recognize sub-acute or sub-lethal contamination because the effects are much less noticeable. Thus, water quality standards sufficient to prevent gross pollution may not be adequate to prevent significant pollution.

"A great deal remains to be learned through research projects. Especially important are careful physiological and ecological studies of aquatic organisms and of water-borne disease-carrying organisms. These programs take a great deal of effort, skill and time.

"Not only are more adequate marine biological and hydrographic studies needed, but sanitary and chemical engineers must solve the problems of recovering phosphorus and nitrogen and other fertilizers from treated wastes. New solutions to erosion control, especially in construction areas, must also be sought.

"Through the continued efforts of science, technology, government ana industry the serious problems of pollution can be solved. Then we can achieve the ideal minimum contamination of our streams and estuaries. Pollution prevention can be hastened by scientists learning the characteristics of the waters themselves, their bottoms and their marine life."

FIGHT DIRTY WATER!