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F. M. MIDDLETON,* M. J. GROMIEC**

OVERVIEW OF WASTEWATER REUSE PRACTICES

The intent of this paper is to indicate the present extent of the possibilities for wastewater reuse. The importance of standards for wastewater reuse is pointed out, and specific considerations governing different types of reuse are presented. The present status of wastewater reuse practices in the United States and of reuse operations in other countries is given.

1. INTRODUCTION

Water has always been used and reused by man. The natural water cycle, evaporation, and precipitation is one of reuse since the return of wastewaters to the streams and lakes is a fact of life. The unplanned reuse of wastewaters is not new, and the planned reuse of wastewaters for beneficial purposes has been done in some areas for many years, but at the present time a concentration of efforts for far greater use of wastewater is needed.

Wastewater reuse means the use of treated wastewater for any purpose. The wastewater reuse can be divided into indirect and direct reuse. Indirect reuse of wastewater occurs when water already used one or more times for domestic or industrial purposes is discharged into fresh surface or underground water and is used again in its diluted form. Direct reuse is the planned and deliberate use of treated wastewater for some beneficial purposes such as irrigation, industry, prevention of salt water intrusion by recharging underground aquifers, recreation, and potable use. Potable reuse can be further divided into two categories as follows:

— indirect potable reuse — the planned addition of treated wastewater to a drinking water reservoir, undeground aquifer, or other body of water designed for potable use that provides a significant dilution factor;

— direct potable reuse — the planned addition of treated wastewater to the headworks of a potable water treatment plant or directly into a potable water distribution system.

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* Municipal Environmental Research Laboratory, Environmental Research Center U.S. Environmental Protection Agency, Cincinnati, Ohio 45268, U.S.A.

** Resources Development Coordination Group for Govermental Programme, Institute of Meteorology and Water Management, 61 Podleśna, 01-673 Warsaw, Poland.

In recent years considerable efforts have been directed on the development of advanced wastewater technologies to alleviate the water pollution problem and to reclaim wastewater for deliberate use.

2. STANDARDS FOR WASTEWATER REUSE

To ensure the safety of water supplies, standards have to be applied. Standards for drinking water have been available for many years.

Although national standards may be set for drinking water, the qualities of river water, industrial effluents, and reused wastewater are the responsibility of the local controlling authority. Even so, the standards set must take into account the possible transport of pollutants and the effects of discharges on downstream water users. As wastewater reuse develops, it is important that standards be set for specific reuse purposes. Standards setting is a most difficult and critical job, with important economic implications, and standards

Table 1

Water quality requirements for South Tahoo and Lancaster [8]

Parameter	South Tahoo and Lancaster	South Tahoo	U.S. Public Healst Service Drinking Water
	Lahontan	Alpine County	
Turbidity, Jtu	3–10	5	5
PO_4, mg/dm^3	0.1–0.5	No requirement	—
pH	6.5–7.0	6.5–8.5	6.0–8.5
BOD, mg/dm^3	5–10	<5	—
COD, mg/dm^3	45–75	<30	—
DO, mg/dm^3	7–15	—	4–7.5
Algae, counts/cm^3	0–10, 000	—	—
Coliforms, MPN/100 cm^3	0–2.2	Adequate disinfection	1 —
Temperature, C	10–30	—	—
SS, mg/dm^3	10	<2	—
TDS, mg/dm^3	500–650	—	500
Ammonia nitrogen, mg/dm^3	0.1–15.0	—	—
Organic nitrogen, mg/dm^3	1.0–3.0	—	—
Nitrate nitrogen, mg/dm^3	1.0–4.0	—	45
Total nitrogen, mg/dm^3	3–20	—	—
Total alkality, mg/dm^3	74–140	—	—
Hardness, mg/dm^3	85–110	—	—
MBAS, mg/dm^3	2–4	<0.5	—
Boron, mg/dm^3	0.8–1.4	—	—
SAR	5–7	—	—
Rosidul chlorine, mg/dm^3	0.5–2.5	—	—
CO_2 mg/dm^3	1	—	—
ABS, mg/dm^3	7–15	—	0.5

must be given the force of law, an and authority must be created to ensure that they are observed.

Standards governing the quality of water in rivers and lakes are becoming common. Some countries have, and others are formulating standards applicable directly to effluents, though few countries yet have standards for the planned reuse of treated wastewater.

Table 2

Existing standards governing the use of renowated water in agriculture [6]

	U.S.A. California	Israel	South Africa	Federal Republic of Germany
Orchards and vineyards	Primary effluent; no spray irrigation; no use of dropped fruit	Secondary effluent	Tertiary effluent heavily chlorinated where possible. No spray irrigation	No spray irrigation in the vicinity
Fodder, fibre crops, and seed crops	Primary effluent: surface or spray irrigation	Secondry effluent, but irrigation of seed crops for producing edible vegetables not permitted	Tertiary effluent	Pretreatment with screening and settling tanks. For spray irrigation, biological treatment and chlorination
Crops for human consumption that will be processed to kill pathogens	For surface irrigation, primary effluent. For spray irrigation, disinfected secondary effluent (no more than 23 coliform organisms per 100 cm^3)	Vegetables for human consumption not be irrigated with renovated wastewater unloss it has been proparly disinfected (<1000 coliform organism per 1C0 cm^3 in 80% of samples)	Tertiary effluent	Irrigation up to 4 weeks before harvesting only
Crops for human consumption in a raw state	For surface irrigation, no more than 2.2 coliform organisms per 100 cm^3. For spray irrigation, disinfected, filtered wastewater with turbidity of 10 units permitted, prowing it has been treated by coagulation	Not to be irrigated with renovated wastewater unless they consist of fruits that are peeled before eating		Potatoes and cereals-irrigation through flowering stage only

As wastewater — treated or untreated — has been reused in agriculture for a fairly long time, some countries have development standards for this purpose. In California quality standards for irrigation and recreational uses of reclaimed water have been established, and regulations relating to treatment reliability are in process of being adopted.

General characteristics of reclaimed water used for recreational purposes should include the following criteria [7]: Dissolved oxygen concentrations must be above levels to support game fish, and the organic concentrations must not exert an oxygen demand which lowers dissolved oxygen concentrations below acceptable levels. In addition, dissolved oxygen levels can be affected by heavy algae growth or formation of an ice covering.

Table 3

Limits of pollutants for irrigation water recommended by EPA [9]

Constituents	For water used continuously on all soils (mg/dm^3)	For short-term use* on fine-textured neutral and alkaline soils (mg/dm^3)
Heavy Metals		
Aluminium	5.0	20.0
Arsenic	0.1	2.0
Beryllium	0.1	0.5
Boron	0.75	2.0
Cadmium	0.01	0.05
Chromium	0.1	1.0
Cobalt	0.05	5.0
Copper	0.2	5.0
Fluoride	1.0	15.0
Iron	5.0	20.0
Lead	5.0	10.0
Lithium	2.5	2.5
Manganese	0.2	10.0
Molybdenum	0.01	0.05
Nickel	0.2	2.0
Selenium	0.02	0.02
Vanadium	0.10	1.0
Zinc	2.0	10.0
Chemical		
TDS	500	
PH	4.5–9.0 units	
Bacterial		
Coliform density	1000/100 cm^3	

Short-term used herein means a period of time as long as 20 year.

Nitrogen and phosphate compounds stimulate unaesthetic algal growth and accelerate eutrophication. Ammonia can be toxic to fish. The level of toxicity depends upon other water characteristics, including pH, dissolved oxygen and carbon dioxide concentrations. Fecal coliforms are indicative of the presence of pathogenic bacteria and viruses which can cause serious diseases. Table 1 shows quality standards for plants discharging effluents to recreational lakes that have been established by regional water quality control boards in The State of California. The drinking water standards are not presently complete enough to be utilized with a renovated wastewater [2].

A summary of some representative standards for the use of renovated water in agriculture is given in table 2. Limits of pollutants for irrigation water recommended by the U.S. EPA are presented in table 3. The limits established are only general guidelines and cannot be used as absolute standards.

3. SPECIFIC CONSIDERATIONS GOVERNING REUSE

3.1. GENERAL

Usually the reuse of treatment effluents is most applicable where large volumes of water are used. The possible transport of the renovated water is an important consideration. A wastewater renovation plant need not always be located at the same place as the municipal wastewater disposal plant, nor should the renovation process be dependent upon treating the total flow. Treatment processes work most efficiently and economically when dealing with a steady flow of wastewater rather than with the irregular flow normally experienced from urban sources, and this condition can be obtained by withdrawing only a part of the urban wastewater.

3.2. DOMESTIC REUSE

In any reuse application there are a number of points to consider. One very important question is whether the reuse will result in multiple recycle. Multiple recycle produces a buildup of refractory materials, especially inorganic ions, and may require the use of demineralization or other specialized processes. In-plant reuse of industrial water, where actual consumption is small, may lead to high degree of recycle. On the other hand reuses of municipal wastewater, except for domestic reuse, probably would not lead to multiple recycle. Even in the case of domestic reuse there is not likely to be total recycle. The reason is that less water is ordinarily found arriving at the wastewater treatment plant than is supplied to the municipal water system. Water losses in municipal systems are the result of water treatment, distribution and use and from collection, treatment and disposal of wastewaters. Such losses do occur and are quite large in warm, dry areas where domestic reuse is likely to be most widely practiced.

In the United States it is estimated that these losses range from less than 20 per cent in humid areas to about 60 per cent in arid areas. The disadvantage of these losses is the need for a substantial additional fresh water source. The advantage is that the steady state mineral concentration is reduced. As a result, the degree of demineralization may be reduced substantially below that needed if there were no losses. Also, there is the flexibility of demineralizing either the renovated wastewater or the supplementary water source; there may be advantages to demineralizing the supplementary source.

Another consideration in reuse is the character of the wastewater entering the treatment plant, especially with respect to industrial pollutants. Care must be used to exclude materials that would be determinal to the reuse application. This is especially true for domestic reuse, but also applies to less sophisticated reuse applications. These materials may not be those usually considered toxic. Ordinary salt brines would be undersirable, for example, if demineralization was being carried out on the renovated wastewater. In Los Angeles County, a survey of the sewer systems has been made to determine how much of the available wastewater has potential for reuse. Waters having heavy metals contamination or high total dissolved solids were considered unacceptable. A similar survey will be necessary for other municipalities planning extensive reuse.

Another point that must be considered is distribution of the renovated water. A multiplicity of piping systems, each one containing a different quality renovated water, will not usually be practical. There may be a number of large consumers in the vicinity of the treatment plant. This would make distribution simple and inexpensive. If the consumers are widely distributed, however, one piping system in addition to the existing municipal water system is almost certain to be the most that will be economically realistic. The result is that the renovated wastewater must be of a quality to satisfy most of the customers without additional treatment. Treatment such as those necessary for boiler water feed would be excluded, since present practice in water supply has shown that those treatments are more appropriately carried out by the user.

3.3. INDIRECT REUSE

In indirect reuse of the increasing proportion of wastewaters in many rivers should be considered.

In a number of rivers in the United States from about 4 per cent to about 20 per cent of the water has passed through domestic waste systems at periods of low flow. If the volume of industrial effluents is also taken into account, it would be expected that 20 to 40 per cent of the river water at low flow in some areas may be reused water.

The Ruhr River in FRG has a reuse factor of 36 per cent half of the time and has reached 86 per cent under severe conditions. At the 86 per cent concentration of effluent it was reported that 7 per cent of the population of Essen, FRG had non-bacterial gastroenteritis. In the United Kingdom, the River Thames, which provides two-thirds of the water supply for the Greater London area, contains about 14 per cent of sewage effluent when flowing at an average rate. During the severe drought in 1975 the flow in the Thames dropped from a daily volume of 35 cu m per second to 22 cu m per second and the flow was nearly all effluent.

Also, it is important to know the amount of present reuse and to forecast for future reuse. The content of effluent in the Great Ouse River at Clapham, United Kingdom was 40 per cent in 1971, and it is estimated that concentration of effluent in the water will increase to 75 per cent by the year 2001. The River Authorities in the United Kingdom, according to BILLINGTON et al. [1] have formulated a guideline suggesting a maximum limit of 75 per cent sewage effluent in rivers.

In the treatment of polluted rivers, the methods employed at present are based upon those developed over the years for the treatment of relatively unpolluted river water, and it appears that sufficient note may not have been taken of the increasing proportion of wastes in many rivers.

The inadequacy of these traditional methods may perhaps be indicated by the outbreaks of infectious hepatitis in New Delhi in 1955–1956 and in 1958. The waterworks in question was of modern design and, though there may have been some faults in operation, they were of the sort that may occur at any waterworks. However, at the time of the outbreak drought conditions prevailed, and the water abstracted from the river was estimated to contain 50 per cent of sullage water.

It appears, therefore, that the public health aspects of the production of potable water from polluted rivers should be reviewed. When rivers contain a high proportion of effluent, the production of water from them should be regarded as analogous to the direct recovery of water from a sewage or industrial effluent, and safeguards appropriate to this situation should be imposed.

There is also an increasing need to consider the optimum distribution of purification between the wastewater treatment plant, the river (self-purification), and the treatment plant that produces potable water. There are two extreme cases:

— wastewater is discharged with little or no treatment, all the purification occurring in the river or at the water treatment plant;

— the wastewater is purified to a standard as high as that of the river water into which it is discharged.

In the first case this practice has been common in the past but is rapidly disappearing. In fact, raw sewage disposal into rivers is prohibited in some countries. Local authorities are requiring secondary treatment and in some cases, the removal of the nutrients, phosphorus and nitrogen, because incidential pollution that is as yet uncontrolled may well use up the natural purifying capacity of the river. In the second case the type and degree of purification required at the water treatment plant is no different from that which would be required in the absence of the wastewater discharge.

Almost certainly the optimum solution lies somewhere between these two extremes, and optimization studies are required to determine it, taking into account all the costs and benefits involved. This may be difficult in practice because some of the social costs and benefits cannot readily be expressed in economic terms. Such optimization studies are likely to be most successful in the context of a single river basin authority having control over the treatment and discharge of wastewaters and also over the abstraction and treatment of potable waters.

The unintentional reuse of wastewater also occurs widely as a result of the use of river water for agriculture, recreation, and industrial supply and for these purposes, too, there is a need for appropriate safeguards.

3.4. DIRECT REUSE

Treated wastewater may be deliberately used in a planned way for a variety of purposes.

The direct reuse of municipal wastewater is becoming more attractive for two primary reasons:

— regulatory agencies are imposing increasingly stringent standards on sewage treatment plant effluent;

— population increases in many urban centers are placing an added burden on traditional fresh water supplies.

However, it is not expected, nor is it desirable, that renovated effluents will be piped directly to potable water systems. Some dilution, storage, or other time-holding barrier can usually be provided. In such systems where the interval from effluents to potable waters is short, not only will advanced treatment be given to the effluents but normal water purification procedures will be applied before the water is distributed. A variety of direct and other reuse applications of effluents has been published by the World Health Organization [6]. Also a comprehensive survey of demonstrated reuse technology has been made by SCS Engineers [7].

4. WASTEWATER REUSE PRACTICE IN THE UNITED STATES

The following presentation of the present status of wastewater reuse in the United States is based largely on a survey [2], [7] made for the U.S. Environmental Protection Agency. According to the survey, the 1971 total volume of municipal wastewater reuse was about 500 million cubic meters, exclusive of ground water recharge. Reuse operations are mainly concentrated in semi-arid southwestern United States (of the 358 sites practicing reuse, 306 are located in Texas, California and Arizona).

The dominant utilization of reclaimed wastewater is for irrigation purposes, accounting for about 291.4 million cubic meters of effluent annually at 338 locations. Irrigation of a variety of crops was reported, but the use of wastewater for irrigation of crops for human consumption is limited. About 75 per cent of the total effluent volume reused for irrigation has undergone secondary treatment. Most operations have storage time of two days or more, and many irrigation sites are located up to 6.5 kilometers.

The survey indicated that the reuse of municipal wastewater effluents by industry amounted to 202.5 million cubic meters in 1971, or 40 per cent of the total United States reuse volume. The major industries using municipal wastewater are power generation, petrochemical, mining and ore processing, and basic metal manufacturing.

Cooling is predominant in the reuse of municipal wastewater due to one user, the Bethlehem Steel plant at Baltimore, Maryland, which utilizes 166.5 million cubic meters annually for once — through cooling. Municipal effluents are used both once — through cooling and recirculating cooling systems. In once — through system secondary effluent has been used, but in recirculating systems shock chlorination, lime clarification, pH adjustment, corrosion inhibitors, filtration, and softening have been applied.

Table 4

Typical plant performance supplying wastewater for recreational lakes [8]

Parameter	South Tahoe public utility district plant effluent	Santee County water district after infiltration	Lancaster water renovation plant effluent
pH	6.9–8.6	7.7	6.2
BOD, mg/dm^3	0.7–3.2	3.5	0.4
COD, mg/dm^3	12.0–28.7	41.0	35.0
SS, mg/dm^3	0	5–10	5.0
TDS, mg/dm^3	250	1150	554
Ammonia nitrogen, mg/dm^3	23.0–35.0	0.36	1.0
Nitrite nitrogen, mg/dm^3	0.01–0.27	0.01	0
Nitrate nitrogen, mg/dm^3	0.01–0.9	1.0	1.9
Total phosphate, mg/dm^3	0.17–0.41	3.6	0.29
Turbidity, Jtu	0.3–0.5	5.0	1.5
Alkalinity, mg/dm^3 $CaCO_3$	187–308	240	65
Total hardness, mg/dm^3 $CaCO_3$	110–164	400	68
Sulphates, mg/dm^3	15–16	340	—
Chlorides, mg/dm^3	30	250	—
Chlorine residual, mg/dm^3	0.6–2.2	0	3.4
Coliforms MPN/100 cm^3	<2	<2	<2.2

In addition to cooling the wastewater effluent is used for makeup to boilers and for processing purposes. The treatment steps used to produce satisfactory water for low pressure boilers have included lime clarification, recarbonation, anthracite filtration, zeolite softening, and deareation. The additional treatment steps have been applied for a high pressure boilers in the form of reverse osmosis, demineralization through cation and anion exchangers, and mixed bed exchangers for polishing. Reclaimed wastewater effluents have been used for processing purposes in the mining and steel making industries.

Approximately 6 million cubic meters of treated effluent is used for recreational purposes. There are three municipal treatment plants that discharge treated effluents to recreational lakes, all located in California in the cities of Santee, Lancaster, and South Tahoe. The cost of treatment by these plants ranges from about 4 cents per cubic meter at Lancaster to about 23.5 cents per cubic meter at Lake Tahoe. At Santee County Water District lakes project aerated lagoons effluent is given additional treatment by coagulation, filtration, and chlorination. Treatment system at Lancaster (Los Angeles County) includes oxidation ponds followed by flocculation, sedimentation, filtration, and chlorination. The South Tahoe wastewater is treated by activated sludge, lime addition, ammonia stripping, filtration, carbon adsorption, and chlorination. Ultimately, the reclaimed water is exported from the Lake Tahoe watershed to Indian Creek Reservoir. Some typical values of selected effluent parameters are presented in table 4. Fish propagation in treated municipal effluent has been reported, but there are no commercial fish farming operations in the U.S. that utilize reclaimed wastewater. The use of reclaimed wastewater for domestic purposes is highly controversial in the U.S. The only known case in the U.S. where treated municipal effluent is used for a domestic purpose is at Grand Canyon Village, Arizona. The Grand Canyon treatment system consists of conventional activated sludge, anthracite filtration, and final chlorination. Wastewater effluent is used for flushing public toilets, irrigation of football field, and for landscaping purposes. Some quantities are used for stock watering, vehicle washing, and road construction. The total amount of the direct reuse of reclaimed water is only about 40 thousand cubic meters annually. Presently, The City of Denver, Colorado is also engaged in a long-term programme which is aimed at achieving direct reuse by 1990.

Reclaimed municipal effluents are also used for groundwater recharge and/or salt water intrusion barriers at ten locations in the U.S. The total amount of the wastewater used for this purpose is about 240 thousand cubic meters daily.

5. REUSE OPERATIONS IN SELECTED COUNTRIES

Wastewater is reused in many countries, and by far the largest reuse is irrigation. In some cases raw sewage is used to irrigate grazing lands, vegetables, and grasses but this practice is not generally recommended. A survey of wastewater made by the World Health Organization [6] showed that in addition to municipal waters, discharges from breweries, starch factories, textile works, dairy farms, and slaughter houses are used for irrigation purposes. The industrial use of effluents is becoming more common, and recycling within the factory itself is extensive. When effluents are used in industry, it is common to treat the effluent with chemicals, followed by filtration or other advanced processes depending upon the quality of the water needed. Recreational uses for wastewater exist in a number of countries in the form of artificial lakes, and parks and golf links are also watered with treated effluent. As would be expected, the driest countries with growing populations are the most likely to turn to reuse first.

AUSTRALIA

Australia is regarded a dry continent and the concentration of populations causes some water resources problem. The City of Melbourne has made unique reuse of the city's wastewater by irrigation of otherwise barren land to graze large number of cattle and sheep. A net income of $ 0.5 million was earned from the livestock operation in 1973–1974. The water management approach of Melbourne is described by CROXFORD [3]. The Ministry of Water Supply of the Victorian State Goverment at Melbourne established a Reclaimed Water Committe in the early 1970's and are preparing a master plan for reuse for high quality purpose by the year 2000.

ISRAEL

Israel is a good example of country that is water-short and, by necessity, very active in the wastewater reuse field. Water supply in Israel for agricultular, industrial, and municipal purposes currently requires over 90 per cent of the country's potential water resources. By 1980 there will be a water deficit, and by the year 2000 it will reach major proportions. In 1973 about 20 per cent of the available municipal wastewater in Israel was utilized for agricultural purposes.

Israel is proceeding with major planned reuse projects, and a full development of reuse potential is expected. Even with full reuse Israel will possibly have to resort to desalination of sea water eventually for supplementary supply. A major undertaking that will be watched with great interest is in the Dan Region wastewater utilization project. The City of Tel Aviv and six neighboring municipalities have joined together to form the Dan Region Sewage Association to solve their common wastewater disposal problems. For many years the sewage in this area has been going to the sea. In the early 1960's, however, a project was instituted to solve the problem of beach pollution and to provide for the reclaiming and recycling of large volumes wastewater. In Dan Region project is now in an advanced stage of design and construction. The wastewater will be processed by biological and chemical treatment and then pumped to recharge basins located on the sand dunes south of Tel Aviv. The water will be pumped from the aquifer by series of recovery wells located several hundred meters away from the recharge basins. Total residence time in the aquifer will be about 400 days. The reclaimed water will be mixed with the groundwater already present in the aquifer.

The reclaimed water will then receive some final polishing treatment and possibly further dilution depending upon its intended use, and will be conveyed to the Negev area south of the Dan Region. The reused water will, thus, be a one-pass system and not one of multiple recycling. The initial uses of such water would be for non-potable purposes, but the planners are looking ahead to assuring the possibility of potable use. The cost of reclaiming the wastewater may be as much as $ 0.32 per cubic meter, but this amount is not considered excessive in a water-short land.

JAPAN

Japan is well aware of the value of water and the possible reuse of wastewaters. According to IKEHATA [5] the use of regenerated wastewater for potable water is not likely in Japan and even some non-potable use has met with some citizen objections.

In 1973 Japan established a Reuse Promotion Center at Tokyo. The objective of the Center is to promote the development and practical application of water reuse technology, by reclamation of wastewater and desalination of sea water in order to cope with the very acute water demand in Japan. The main activities are as follows:

— construction and operation of test plants for water reuse,
— promotion of the research and development of water reuse technology,
— consulting services on construction of water reuse plants,
— training of water reuse engineers,
— establishment of standards for water reuse facilities and certification of their performance,
— information service about water technology,
— survey on water reuse,
— promotion of international cooperation in the field of water reuse.

MEXICO

Large areas of Mexico are arid or semi-arid. Wastewater reuse is vital in these areas. Several industries in Monterrey are supplied with chlorinated activated sludge effluent. The plants then treat the effluent further for the specific use required. In Mexico City, Chapultepec Park uses treated wastewater effluent for irrigation and to supply water to two lakes. Several other areas of the city use effluents for irrigation.

SOUTH AFRICA

South Africa has long recognized the importance of wastewater reuse, and the country does not expect to have enough freshwater resources by the year 2000. The City of Windhoek, Namibia has already had to resort to the reclamation of municipal wastewater to augment its potable supply. An advanced waste treatment system was installed in 1968 to treat the wastewaters for the city, and up to one — third of the city's water was supplied from the renovated product. Subsequently, the water supply source improved somewhat, and the reclamation plant was shut down. The renovation plant is now being rebuilt on a larger scale, however, and it is fully expected that it will be needed in the future. South Africa has made very good use of municipal effluents for industrial purposes. In nearly all cases, the major use is for cooling but some of the water can be used for steam generation, and the remainder for processing.

UNITED KINGDOM

The United Kingdom has had little need so far to consider very much direct reuse of wastewater. They have, however, made use of such waters industrially. A particularly interesting project has been the development of a direct reuse of sewage effluent in the processing of wool textiles. The wool textile industry has some high water quality requirements, but appropriately treated sewage effluents were found to provide an ample source of sufficiently high-quality water [4].

The Water Research Centre in the United Kingdom in their programme plan for 1976/77 list a project relating to assessing the effects of water reuse under present conditions. The main elements of this plan are:

— determination whether there is any relationship between the mortality and morbidity from chronic disease and the degree of contamination from sewage effluents in the drinking water supply,

— determination of the acute toxicity to animals and the mutagenic activity from the drinking water with various amounts of sewage effluent.

CONCLUSIONS

Many countries such as South Africa and Israel have urgent needs for wastewater reuse. Some countries as the United States are in the fortunate position of not needing to immediately turn to wastewaters as a direct source for preparing potable waters. Therefore, a small percentage of municipal wastewater is presently reused in the United States and many reuse opportunities still remain unrecognized. In ten or twenty years it will be a necessity in many parts around the world to reuse wastewater. Since a long time is usually needed to bring research results into practical use the time to develop and provide full-scale reuse is short. Therefore, it is the responsibility of scientists and engineers around the world to provide the scientific and technological base to permit reuse for all purposes.

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PRZEGLĄD BADAŃ NAD ODZYSKIEM ŚCIEKÓW

Przedstawiono zakres obecnie istniejących możliwości odzysku ścieków. Zwrócono uwagę na znaczenie norm i specyficznych warunków przebiegu różnego rodzaju procesów odzysku ścieków. Podano obecny stan badań prowadzonych w Stanach Zjednocznych i innych krajach.

ERRUNGENSCHAFTEN IN DER WASSERRÜCKGEWINNUNG

Im Bericht werden die zur Zeit bestehenden Möglichkeiten der Wasserrückgewinnung aus dem Abwasser erörtert. Spezieller Augenmerk wird der Bedeutung der Normen und den spezifischen Bedingungen der verschiedenen Rückgewinnungsverfahren gewidmet. Zusammengefasst wird der jetzige Stand der Versuche in den Vereinigten Staaten und in anderen Ländern.

ОБЗОР ДОСТИЖЕНИЙ В ОБЛАСТИ РЕГЕНЕРИРОВАНИЯ СТОЧНЫХ ВОД

Описаны имеющиеся возможности регенерирования сточных вод. Уделено внимание значению стандартов и специфических условий для протекания разных процессов регенерации названных вод. Описано нынешнее состояние в области исследований, проводимых в Соединенных Штатах Америки и других странах.