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Water Pollution in the USSR and in Other Eastern European Countries*

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The condition of water bodies and measures taken to prevent their pollution in the USSR, Czechoslovakia, Poland, Bulgaria and Romania are the main subjects of this paper. For each of these countries information is given on population and area, physical features, rainfall and rivers, the distribution of population and industry, water supply and sewerage, the condition of surface and ground waters, the authorities and legislation concerned with the protection of water resources, and research on pollution.

The author draws attention to the experience gained in these countries in the setting up of special State bodies to take charge of water resources and in classifying rivers according to the uses to which they are put, a factor which determines the regulations governing the discharge of effluent into them. A plea is also made for the convening of specialized international conferences on problems connected with the protection of European water resources from pollution.

UNION OF SOVIET SOCIALIST REPUBLICS

Population and territory

The Union of Soviet Socialist Republics consists of 15 member republics (" Union Republics "). The territory of the Union covers 20 402 200 km². Its total cultivated area for all crops in 1959 amounted to 196 300 000 million hectares.

The population of the country is 208 826 650, the density varying greatly. In the European part of the country it ranges up to 30 persons per km², except in the Ukraine where it is as high as 68, and in the Black Earth country where it is as much as 100 and more. In Siberia the population density is lower, particularly in the northern regions and mountainous areas.

Physical features and rainfall

The USSR is situated in eastern Europe and in northern and central Asia.

A large part of the country lies in the temperate zone, while the northern regions are within the Arctic Circle and some southern parts in the subtropical belt.

The following are the main geographical types of country into which the USSR can be divided: arctic wastes, tundra, forest, steppe, temperate, desert and subtropical. There are certain intermediate zones of forest-tundra, forest-steppe and, in the temperate zone, of semi-desert.

The arctic wastelands include the majority of large islands in the Arctic Ocean and a part of the mainland. The climate is cold and the temperature in the warmest month varies from −3°C to +2°C. The rainfall decreases from west to east, the average being between 200 mm and 250 mm annually. The ground remains permanently frozen.

The tundra zone covers mainly the coasts of the Arctic, part of the shores of the Pacific Ocean and some of the southern Arctic islands. In these parts the climate is somewhat warmer with average temperatures in the warmest month of between +5°C and +10°C and even up to 12°C. The annual rainfall in the European part of the area is 400 mm, in eastern Siberia 200-250 mm, and in the Far East 300-500 mm. Marshland is widespread and the ground is nearly everywhere frozen all the year round.

The forest-tundra zone has slightly higher temperatures, reaching 10°C-14°C in the warmest month of the year. The rainfall in this zone is be-

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tween 200 mm and 300 mm annually. The ground almost everywhere remains frozen all the year round.

The forest zone has the largest area of all the climatic zones of the USSR. It stretches from the western frontiers to the shores of the Pacific Ocean. The climate is moderate with a cold and comparatively long winter, and with warm summers. Average monthly temperatures in summer reach 20°C, though in the eastern regions the ground still remains frozen throughout the year in many parts. The rainfall varies between 500 mm and 600 mm in the western regions, going down to 200 mm and somewhat less in the central areas, and rising again to between 500 mm and 900 mm in the Far East.

The forest-steppe zone is typically a mixture of steppe and forest country with a temperate climate, hot in summer; average temperatures in July reach 20°C-22°C and the rainfall varies between 350 mm and 550 mm annually.

The steppe zone, including in parts forest-steppe and semi-desert areas, stretches from the lower reaches of the Danube to the Altai Mountains and the Saur. In addition, steppes extend from Mongolia into the southern part of the Transbaikal region. In southern Siberia there are some isolated steppe areas: the Minusinsk, Tuva and other steppes. The main feature of the steppe zone is its dry continental climate with hot summers; the average temperature in July is between 21°C and 23°C. The rainfall decreases from 450 mm in the north to 250 mm in the south. There is also a decrease to be observed going from west to east and droughts are not infrequent in the south-eastern parts. The steppe and forest-steppe zones are those which have been brought most under agriculture.

The semi-desert belt in the temperate zone has a continental climate subject to drought, with evaporation sharply exceeding rainfall. The winter is cold and the summer long and hot. The average temperature in July may rise to 27°C.

The desert areas of the temperate zone are in the south of the USSR, mainly in the Asiatic part (Central Asia, Kazakhstan). In the European part of the USSR the semi-desert reaches only to the south of the Caspian depression. The climate is continental and very dry, the winters are cold and the summers very hot. The average July temperature reaches between 27°C and 32°C and the rainfall is between 100 mm and 200 mm a year.

The subtropical areas comprise comparatively small and isolated regions of the USSR: the Colchis Depression (in Transcaucasia, on the Black-Sea coast), and the Lenkoran depression (on the shores of the Caspian). The climate is damp and warm and average temperatures in the winter months are above zero. The summer is hot with average temperatures in the warmest month of 23°C-24°C. The rainfall is over 1000 mm and in places up to 2500 mm in a year.

Thus, the climate of the USSR varies from a cold Arctic one in the north to subtropical or desert conditions in the south. Moving from west to east the climate changes from maritime to severely continental and then to a monsoon climate on the shores of the Pacific.

In altitude the territory of the country is extremely varied. The western half of the USSR consists of extensive plains—the Russian or East European Plain—and depressions such as those of Western Siberia and Turon. In the south-east, highlands and plateaux prevail. An almost unbroken line of high mountain ranges runs along the whole southern and eastern frontiers of the country: the Carpathians, the mountains of the Crimea, the Caucasus, the mountain systems of Central Asia, southern and north-eastern Siberia, and the mountainous areas of the Soviet Far East.

Altitudes within the USSR vary by more than 7600 m. The highest point is 7495 m in the Pamirs and the lowest is the Karagi Depression on the Mangyshlak Peninsula on the Caspian Sea, which lies 132 m below sea level. The northern part of Asia, beyond the Urals, rises in three giant steps in the direction of the Pacific Ocean from the West Siberian depression to the Central Siberian Plateau and the mountainous Far East. The higher mountain ranges are glacial, and the glaciers at present existing in the mountains of Central Asia, the Caucasus and the Altai are very large.

Rivers

The rivers of the USSR run into three oceans—the Arctic, Atlantic and Pacific—and into the Eurasian inland drainage system. A large portion of the river system in the USSR belongs to the Arctic Ocean basin, including the adjacent Barents Sea, White Sea, Kara Sea, Laptev Sea, Eastern Siberian Sea and the Sea of Chukotsk. The rivers in the west of the European part of the USSR flow into the Baltic, the Black Sea and the Sea of Azov, forming part of the Atlantic system.

To the east, in the Asiatic part of the USSR, the Arctic Ocean basin joins on to the Pacific Ocean basin with the Sea of Japan, Sea of Okhotsk and Bering Sea. These three ocean basins surround the extensive enclosed central Eurasian region, which includes the Caspian basin and those of Central Asia and Northern Kazakhstan.

The Arctic Ocean basin covers the most extensive area with some 11 700 000 km², amounting to 54.1% of the entire area of the USSR, while the smallest basin is that emptying into the Atlantic Ocean and covering 1 800 000 km², or 8.4% of the total area.

In the European part of the USSR much of the territory is drained by rivers flowing from north to south; in the Asiatic part, on the other hand, most of the rivers empty into the Arctic, flowing from south to north. The total area covered by inland basins throughout the USSR covers 24.8% of the country's territory.

There are more than 700 000 rivers in the USSR, including some 150 000 more than 10 km in length. The total length of these rivers is in the neighbourhood of 3 000 000 km and the total volume of flow approximately 4000 km³ per annum. The total length of river accessible to navigation and timber floating is more than 500,000 km. Table 1 gives particulars of the largest rivers of the USSR.

A vast number of artificial reservoirs have been constructed in the USSR, totalling some 65 000 and ranging from small ponds to immense water-storage reservoirs. In the past few years fourteen such reservoirs have been constructed with an over-all surface area of 56 535 km² and a general capacity of 236 798 km³. At present there are nine reservoirs with a surface of 26 157 km² and a total volume of 409 km³ in process of construction.

There are more than 250 000 lakes in the USSR, five of them (including two inland seas) with a surface area alone of more than 10 000 km² each (the Caspian Sea, the Aral Sea, Lake Baikal, Lake Balkhash, Lake Ladoga). The surface area of fourteen lakes is over 1000 km² each—Lake Onega, Lake Issyk-Kul, Lake Playmyr, Lake Sevan and others. The area of freshwater lakes fed by running water is in the northern part of the country in the zone where there is surplus moisture and the presence of natural hollows coincides with a cool, damp climate. A large number of lakes in the arid region of the Aral and Caspian inland basins in western Siberia and Kazakhstan, which have no outlet to the sea, arise from the innumerable flat depressions without outlet that become filled with water in the spring thaws. In the summer intensive evaporation occurs from the surface of these lakes and their waters have become highly mineralized. In the north-western territory of the European part of the USSR (the Kola Peninsula and Karelian Autonomous Socialist Soviet Republic (ASSR)), and within the confines of the Baltic Shield lies the so-called Glacier Lake Region. Here there are a number of very large, deep lakes, such as Lakes Ladoga and Onega, Imandra and Umbozero (on the Kola Peninsula) and some thousands of others.

Somewhat further south are a series of lakes associated with terminal moraines (those in the Pskov, Novgorod and Velikiye Luki oblasts, the Baltic Republics and others). The biggest of these lakes are Lake Ilmen, Lake Chudskoye and Lake Beloye. Lakes situated between the hills and ridges formed by the moraines are Valdai, Seliger and the Upper Volga Lake.

The tundra zone between the Kanin Peninsula and the lower reaches of the Kolyma is dotted with lakes and, besides these, there are a number of other lake districts in both the European and Asiatic parts of the USSR.

Rivers, reservoirs, lakes and ponds are used for domestic and industrial water supply, for the generation of electric power, for fish-breeding and for agricultural irrigation. The area of irrigated land is more than 7 million hectares and the area drained 8 million hectares.

Distribution of population and industry

Of the total population of 208 826 650, some 48% (100 840 172) live in towns and 52% (107 986 478) in villages.

There are 1682 towns and 3070 urban settlements in the country, mainly situated along the banks of rivers. There is a very large amount of industry in the USSR, distributed throughout the country, and even a general description of its distribution would not be possible in the present paper.

As in other countries, there are industrial districts in the USSR where particular industries tend to be concentrated. Thus, for example, the coal-mining areas are well known—the Donets coal basin, and those of the Moscow region, the Kuznets, Pechora, the Urals, and Karaganda, and the Ekibastuz deposits. The oil fields of Baku, the Volga, the Urals, the Far East, Central Asia and Kazakhstan are equally well known.

The Magnitogorsk, Kuznetsk and Nizhne-Tagil industrial groups and the Chelyabinsk plant in Siberia and the Urals and " Zaporozhstal " in the Ukraine are all important iron and steel centres. Similar districts and centres of industry are scattered

TABLE 1
SOME DATA ON THE LARGEST RIVERS OF THE USSR

Name	Sea into which river flows	Area of basin (1000 km²)	Length (km)	Average annual volume of flow (km³)	Average annual volume of flow (m³/s)
Ob	Kara Sea	2 930	3 680	394	12 500
Yenisei	Kara Sea	2 599	3 354	548	17 400
Lena	Laptev Sea	2 425	4 270	488	15 500
Amur	Tatar Straits	1 843	2 850[a]	346	11 000
Volga	Caspian Sea	1 380	3 690	255	8 130
Kolyma	East Siberian Sea	644	2 600	120	3 800
Dnieper	Black Sea	503	2 285	53	1 670
Don	Sea of Azov	422	1 970[a]	28	900
Northern Dvina	White Sea	360	730	111	3 530
Indigirka	East Siberian Sea	360	1 790	57	1 800
Pechora	Barents Sea	327	1 790	129	4 100
Neva	Baltic Sea	282	74	82	2 600
Olenek	Laptev Sea	246	2 162	35	1 100
Yana	Laptev Sea	245	879	31	980
Amu-Darya	Aral Sea	227	1 460	42	1 330
Ural	Caspian Sea	220	2 534	11	360
Syr-Darya	Aral Sea	219	2 140	14	430
Anadyr	Bering Sea	200	1 170	44	1 400
Pyasina	Kara Sea	192	820	80	2 550
Kura	Caspian Sea	188	1 515	18	580
Taz	Kara Sea	108	1 000[a]	47	1 500
Western Dvina	Baltic Sea	85	1 020	21	680
Anabar	Laptev Sea	82	924	12	370

[a] Approximate figures.

throughout the country, and in this connexion there is one important factor that should be pointed out. With the vast territories and tremendous water resources and river basins of the USSR the effects of the siting of industry on the condition of rivers from the pollution standpoint are not so irrevocable in the USSR as in countries with much more limited territory. In the USSR the threat to surface water supplies from industry is, in comparison with Western Europe, definitely of a more local character.

Water supply and sewerage

During the Second World War thousands of towns, urban settlements and villages were destroyed in the territories of the three republics of Byelorussia, the Ukraine and Russia. Tremendous efforts had to be made and vast sums expended on the restoration of these ruined towns and villages, so that the country did not have the opportunity at the same time to invest the necessary resources in amenities for its other cities.

Out of 1681 towns, 1276 (or 76%) have a piped-water supply. The extent of urban piped-water supplies varies from republic to republic. Thus, in Armenia every single town has a piped-water supply, while in the Russian Soviet Federative Socialist Republic (RSFSR) 84% of towns have a piped-water supply. On an average 111 litres of piped water are supplied per urban inhabitant every 24 hours. In the larger cities this amount is between 140 and 250 litres per inhabitant. In the smaller towns it is between 60 and 100 litres per 24 hours. Some 50%-60% of piped-water supplies goes to meet the needs of industry.

In the great majority of cases the piped-water supplies are taken from rivers and reservoirs; in a smaller number of instances supplies are taken from artesian waters. Where the water is taken from river sources it is purified and disinfected by modern techniques. Sewerage systems in towns and urban settlements are not quite so developed as water supplies. Of the towns and settlements provided with a piped-water supply system, 53% have a sewerage system, and, of this number, more than half discharge their waste waters without prior treatment.

Various methods of purifying and disinfecting sewage are used: sewage farms, use of sewage for agricultural purposes (irrigation), mechanical purification by various sedimentation systems, biological treatment installations with all the necessary equipment, and finally all the various types of special purification equipment for industrial wastes of various types.

There are municipal sewage farms in a number of cities: Odessa, Kiev, Kharkov, Yuzovka, Lugansk and others. The total area of the sewage farms in the cities mentioned is more than 5000 hectares.

Sewage is utilized for agricultural purposes in the Moscow Oblast over an area of 2149 hectares, and the same method is employed by a number of cities.

The most widely used system is that of biological treatment and a number of such sewage works are to be found in many cities including Moscow, Kuibyshev, Kharkov, Dzerzhinsk, Sochi, Kislovodsk and others. In Moscow there are seven biological treatment stations with a capacity of some 3 million m^3 per 24 hours. One of these, with a capacity of 800000 m^3 per 24 hours, is the largest aeration station in Europe, and is fully equipped with all the best and latest technical equipment: racks with comminutors, grit chambers, primary settling tanks, aeration tanks, secondary settling tanks, sludge thickeners, methane tanks, mesophilic and thermophilic digestion, sludge ponds, and installations for the mechanical and thermal dehydration of sludge. Among the purification methods applied to various types of industrial sewage, those used to treat waste waters carrying oil products and phenols deserve attention. At the Kuibyshev Oil Refinery useful results have been achieved with a system of sedimentation ponds. After passing the sewage from the refinery through oil interceptors and a descending series of sedimentation ponds connected by narrow intersecting channels, the content of oil products was sharply reduced to between 6 and 15 mg/l.

Similar results were obtained at the Krasnodar Oil Refinery after introducing, in addition to the oil interceptors, a system of sedimentation ponds. Quite recently, a method of prepurifying oil refinery wastes by means of quartz filters and floatation has been evolved and introduced. These methods reduce the oil products in the waste to a content of 10-12 mg/l.

In treating waste waters containing phenols from solid fuel-processing plants (gas works, gas-generating stations, coke and by-product plants, shale-processing plants and so on) good results have been obtained at Shchekino and at Kokhtla-Yarva by subjecting the waste waters containing high concentrations of phenols to steam distillation for their extraction. This method also wins back marketable products. The waste waters from which the phenol has been removed then undergoes biological treatment together with domestic sewage. This system of treatment almost completely removes the volatile phenols from the sewage.

A number of Ukrainian enterprises have successfully used Putilina's biochemical methods for the treatment of waste waters containing phenol only; phenol-oxidizing bacterial cultures that Putilina has isolated are introduced into the waste.

Good results have been obtained experimentally by using waste water containing phenols previously subjected to biological treatment for coke slaking. Other methods for the treatment of industrial sewage are also under study. In many towns industrial effluents, where their content permits, are discharged into the general sewerage system and treated in common at the local authorities' purification plants. Where this cannot be done, or where the plant is situated outside the town, it has its own separate sewerage and special treatment installation. In certain cases waste waters from individual workshops are treated by special installations and only after this treatment are they discharged into the municipal sewerage system. As regards storm and thaw waters, these are carried away by street gutters and drains or enter the municipal sewerage system which is provided with storm outlets for the disposal of surplus rain and thaw water directly into the receiving water. Such waters are only treated if they enter the purification installations with domestic faecal sewage.

Sanitary condition of rivers and surface waters

The sanitary condition of rivers and ground waters has been and is being systematically surveyed by research institutes, sanitation and epidemiological centres and a number of specialized scientific institutes: the Institutes of Hydrogeology, Biology, Hydrology, Hydrochemistry, Fish-Breeding and others concerned with water supply and sewage, as well as by the Academy of Municipal Economy. Thus, the great majority of rivers in the European part of the USSR have been surveyed, as well as the larger rivers of Siberia and Central Asia.

A number of questions have been investigated, including the physiochemical and bacteriological features of each river, its hydrological regime, self-purification processes, exploitation and the reasons and conditions of river pollution and a whole series of other problems. The main conclusions had been drawn as early as 1937-39 and published in two special works: the first, *Problems of pollution and self-purification of water-supply sources*, published in Moscow in 1937; the second, *The pollution and self-purification of water-supply sources*, published in Moscow in 1939.

Since the war the surveying of river conditions has been extended further to cover the large rivers for the whole of their course (the rivers Volga, Dnieper and others) while measures have been evolved to remove their pollution. The results of these investigations are to be found in a monograph at present in press, *The hygiene of water reservoirs*.

The investigations carried out have disclosed pollution of reaches and tributaries of the rivers Volga, Ola, Kama, Don, Dnieper, Dniester, Northern Dvina, Northern Donets, Southern Bug, Kura, Kuban, Irtysh and a number of others. It is the smaller rivers flowing in close proximity to industrialized districts that are the most polluted. Among these, the rivers Miass, Chusovaya, Iset, Tagil and Neiva in the Urals industrial area can be mentioned, and the Krivoy Gorets, the Krynka, and Kalmius with tributaries in the Donbas, and so on.

Considerable pollution is caused in rivers by oil-transport vessels as well as by pumping oil products from the vessels at oil supply depots sited along the banks of rivers where the transfer of such products to rail tanks takes place.

The protection of the USSR's water resources is regarded as one of the most important duties of the State, and the Government is devoting much attention to the problem.

The main measure against river pollution has been the construction of sewage treatment installations. For this purpose, under the plan for the development of the national economy, funds are allocated annually from the central budget to the local authorities, municipalities and industrial undertakings.

In the Russian Federative Republic—the largest of the Union Republics—funds for the construction of 2032 purification plants were allocated in 1958, and in 1959 for 2179 plants. Some 927 of these plants have already been completed and are now functioning; others are in the final stages of completion, and yet others are still under construction.

Under the Seven Year Plan for the Development of the National Economy 80% of all sewage is to be subject to treatment by 1965.

There is special legislation in the USSR on the protection of water resources. The most important of these measures are as follows.

The first legislative measure that laid the foundation for the planned protection of water resources against pollution was the decree of the Central Executive Committee (TSIK) and Council of People's Commissars (SNK) of 17 May 1937 on the Protection of Water Supply Systems and Sources of Water Supply against Pollution.

A number of subsequent legislative measures obliged industrial undertakings to purify industrial effluents discharged into water supply sources. Newly constructed industrial undertakings were obliged to install equipment for the purification of waste waters to meet with the approval of the State Sanitary Inspection authorities. Special funds are set aside annually from the State budget for the removal of pollution from water-supply sources. These funds are issued to the Ministries concerned, for the construction of sewage purification equipment, as mentioned above.

In 1960 the Government adopted a decree on measures regulating the utilization of water resources of the USSR and for their more effective protection. Special authorities have been set up in the Union Republics under this decree to supervise the utilization and protection of surface and ground-water sources, and special inspection boards have been instituted for the main river basins with the same end in view.

In the USSR rivers are now classified according to utilization, and regulations governing the discharge of waste waters into rivers have been introduced. These classify rivers and sectors of rivers, according to nature of use, into three categories.

The first category covers those sectors of sources that are used for the piped-water supplies or those adjacent to State fish-breeding reserves. The second category covers stretches of water used for piped domestic and drinking-water supplies, and supplies to the food industry, as well as waters where there are fish-spawning grounds of economic value. The third category covers waters within the bounaries of populated areas that are commonly used as bathing resorts or for organized fisheries and so on.

The regulations lay down standards of quality for the different categories of water at point of use. The following, without going into detail, gives the general standards laid down:

Pollution indices	*Category 1*	*Category 2*	*Category 3*
Suspended matter	After discharge of the sewage into the river an increase in the suspended matter content is allowed up to:		
	0.25 mg/l	0.75 mg/l	1.5 mg/l
Odour and taste	The water must not acquire (including chlorination effects) any specific odour or taste.		
Dissolved oxygen	The content in O_2 must not drop below 4 mg/l.		
5-day BOD	2 mg/l	4 mg/l	Not fixed
pH	The inflow of sewage must not raise the pH of the river to more than 6.5-8.5.		
Colour	A mixture of the effluent with distilled water proportionate to the calculated dilution in the river should not have an expressed colour in the height column at:		
	20 cm	10 cm	5 cm
Pathogenic agents	None on discharge of effluent	Discharge permissible only after sedimentation and disinfection.	
Poisonous substances	Must not exceed maximum permissible concentrations in the river.		
Surface pollution	There must be no widespread formation or any continuous floating film of oils, fats or petroleum products on the surface of the water.		

The maximum permissible concentrations of noxious substances entering the rivers with sewage specified in the regulations (see tabulation above) are determined by hygiene research institutes and confirmed by the State Sanitary Inspection of the USSR Ministry of Health. Maximum permissible concentrations for noxious substances in water-supply sources are laid down on the basis of the effects of such substances on the organoleptic properties of the waters (odour, taste), the colour, turbidity formation, the self-purification processes (effect on BOD, and on nitrification, oxygenation, saprophytic microflora and warm-blooded animals). Various toxicological methods are employed in the study of these problems depending on the nature of the substances' effects.

Maximum permissible concentrations have now been worked out for 70 noxious substances encountered in industrial waste waters, as well as for certain combinations of these substances.

In measures taken for the prevention of water pollution as a whole, much attention has been paid to the inclusion of closed circuit schemes for the re-use of waste waters by industrial plants, and to the recovery of valuable utilizable substances (industrial waste, raw materials, etc.).

The attention given by the Government to the protection of the country's water resources, the legislation passed, the systematic practical measures introduced year by year and the annual allocation of State funds for the construction of treatment installations has, in the post-war years, brought about a definite turning-point in the solution of this important national problem. The pollution of rivers as a country-wide phenomenon has been stopped and the condition of certain rivers is improving. For example, the River Chusovaya, which flows through the largest industrial districts in the Urals, was badly polluted by waste waters containing large quantities of phenols, fluorine, iron and chromium. To counter this, a closed-circuit water-supply system was introduced in the gas-generating plant of a cryolite factory to exclude the discharge of phenol wastes into the river. The pre-purification of effluents containing fluorine has reduced the concentration of this chemical in the Chusovaya River to 0.3 mg/l. The introduction of a closed-circuit water-supply system at a potassium bichromate works has greatly reduced the chromium content and suspended matter in the waste water discharged. The construction of a sedimentation pond at a metallurgical combine has reduced the iron content in the effluent. Pollution from waste waters in the Kuban, Belaya, Ural and other rivers has also been considerably reduced as a result of the implementation of practical treatment measures.

Condition of ground waters

Owing to its vast size, the Soviet Union is very well provided with subterranean waters and geological formations of all types, from crystalline rock to quaternary deposits. Artesian waters lying in Devonian, Jurassic, coal and chalk deposits are used for water-supply purposes. Ground-water sources near the surface are to be found in the quaternary deposits. Artesian waters are either found in horizontal beds or form synclines saturated with underground water. Among them are the Moscow Paleozoic basin, the Ukrainian syncline, and certain aquifers in Siberia. A considerable study has been made of underground waters in the Soviet Union by hydrogeologists and hygienists. The hydrogeologists mainly study the distribution of underground waters in the different regions of the country, while the hygienists study the water's composition and work out standards for the assessment of its quality. Much work has been done in investigating the salt constituents of waters by the Institute of Public and Municipal Hygiene of the USSR Academy of Medical Sciences, by the Ukrainian Institute of Municipal Hygiene, and by the Department of Hygiene of the Kazakhstan Medical Institute. From this research work it has been possible to lay down standards for the sulfate content (500 mg/l) and for chlorides (350 mg/l) and these have been included in State Standard 2761-57 on " Sources of Piped Domestic Drinking-Water Supply, Rules for Selection and Assessment of Quality ". State Standard 2874-54 on " Drinking Water Standards " deals with the organoleptic qualities of water, the content in toxic substances, and bacteriological requirements.

Among the chemical constituents, Soviet hygienists attach importance to trace elements of fluorine and iodine that may cause dental fluorosis, caries or affections of the thyroid gland.

In the European part of the country fresh waters have, with few exceptions, a content in salts of up to 1000 mg/l; in the Asian Republics and some European parts of the country, highly mineralized waters are often encountered with a content of up to 2-4 g/l. The high bacteriological quality of underground waters makes them particularly valuable from the hygienic standpoint.

The coal measures, Devonian and Permian deposits and Jurassic and chalk formations offer the most promising sources of water-supply. The aquiferous strata they contain are used as much as possible and provide the largest quantities of water. The carboniferous limestone deposits in the central area of the European part of the Soviet Union are widely used, as are the waters from the chalk in the Ukraine. As regards quality, too, they are in the highest degree satisfactory in meeting the requirements and standards laid down. The great majority of artesian sources are sufficiently well covered by impermeable beds to retain their quality. Nevertheless, in some hydrogeological districts aquifers are encountered that are not sufficiently protected by impermeable beds and here the possibility of pollution cannot be excluded—as, for instance, where the covering is of sand, loams and sometimes even original fissured rock. In some regions, such as the Podolsk and Moscow oblasts, karst areas connected directly to the surface are encountered. The possibility cannot be excluded of certain beds being transformed under the influence of external conditions, so that the impermeable covering beds become liable to infiltration. Ground waters are mainly utilized for drinking-water supplies and it is estimated that approximately 60% of the population draw their supplies from such sources. This is particularly true of the rural population which, as a rule, makes use of ground-water sources, springs and headwaters. On a very rough estimate 15%-20% of ground-water supplies are utilized for industrial purposes.

In rural districts only ground waters are used for drinking purposes, being tapped by means of wells, springs and headwaters. Where wells are concerned, pumps are being widely introduced, and in many collective and State farms piped water-supply systems are being introduced. Water consumption in rural areas is approximately 40-60 litres per person daily. As a rule, water from open sources is used for irrigation, and mechanical equipment is being widely introduced.

As regards its chemical composition, the hardness of the ground waters is in the order of 18° to 20°. However, in some districts, for example, in the southern European part of the USSR and in the Asian republics, the hardness reaches 40° and more.

The same applies to the mineral content, which in most cases corresponds to the hardness and is usually in the region of 1000 mg/l, rising in certain districts where the hardness is high to 2-4 g/l. As a rule, in underground waters, the iron content is of the order of 1 mg/l. Where the iron content is higher, recourse is had to the usual installations for its removal. Reliable data on manganese are not available.

Nitrates and nitrites are not present in the ground waters, though they are encountered in some as a natural phenomenon arising from reduction processes. Fluorine is often encountered in underground waters and not infrequently in quantities sufficient to produce dental fluorisis. At the same time, in some regions, there is insufficient fluorine in the water, giving rise to caries. In some regions (parts of the Moscow, Yaroslavl and other oblasts) there is a shortage of iodine among other trace elements. All surface-water supplies and artesian wells used for piped-water supplies, as well as those in direct common use, are under the constant supervision and control of sanitation and epidemiological centres, of which there are over 5000 throughout the country.

Authorities and legislation concerning pollution

The main legislation for the protection of water resources has been outlined above. Responsibility for implementing measures to control surface- and ground-water pollution under this legislation lies with the economic and industrial undertakings and their appropriate ministries.

It is the responsibility of the State Sanitary Inspection authorities of the Ministry of Health and also of the Fish-breeding Inspection to ensure the implementation of measures for the prevention or removal of pollution and for regulating the conditions under which effluents are discharged into water courses.

The authorities concerned with the utilization and protection of water resources are responsible for regulating and co-ordinating activities in this field and on behalf of the State for seeing that rational use is made of those resources and that the measures against pollution are implemented. These authorities are also empowered to close down enterprises that do not implement measures to ensure the purification and disinfection of their effluents.

The authorities conducting sanitary supervision on behalf of the State:

(*a*) Approve standards of purity of surface and ground waters used for domestic and recreational purposes;

(*b*) Regulate the conditions under which waste waters may be discharged into watercourses, and lay down the maximum permissible concentrations of noxious substances that may be discharged into watercourses;

(*c*) Supervise observance of rules for the discharge of effluents;

(*d*) Participate in the allocation of sites for all types of building, and in the examination of water-supply, sewerage and sewage treatment projects;

(*e*) Survey the condition of water-supply sources and design measures for their long-term improvement;

(*f*) Prepare and submit to the Government proposals for legislation and protective measures for water-supply sources.

Where Government statutes and regulations for the protection of water-supplies from pollution are not carried out, the State Sanitary Inspection authorities and Chief Medical Officers of sanitation and epidemiological stations have the right to apply administrative sanctions against the individuals responsible and legal sanctions extending to the complete closure of the enterprise concerned.

The State Sanitary Inspection authorities and Chief Medical Officers of sanitation and epidemiological stations are present at the handing over of new works, and have the right to prevent them being put into operation if the regulations and standards for the prevention of pollution of water supplies are not implemented or adhered to.

Research

A large number of research institutions and field services (some hundreds in all) are engaged in research on problems of water hygiene and pollution, and it is not possible in the present paper to enumerate them all. Research is being done by ten institutes of hygiene, at all departments of hygiene of medical institutes (there are upwards of 80 such higher medical teaching institutes in the USSR), and at sanitation and epidemiological stations. Further, many technical, chemical, biological, hydrochemical, hydrogeological, planning and fishery institutes, as well as the water-supply and sewage departments of higher educational institutions and universities, water-supply laboratories and so on, are co-operating in such research.

Investigations carried out in recent years range over a number of problems touching the most varied aspects of water hygiene, supply, sewage purification and disinfection, drinking-water standards, purification and disinfection, and the protection of water resources from pollution.

Here, only a few specific problems selected from among the most important being studied by institutes of hygiene can be mentioned.

(1) River pollution: measures for the protection of rivers from pollution (study of hydrological

regime, quality of water, self-purification processes, conditions and causes of pollution, effectiveness of sewage treatment installations, etc.).

(2) Condition of rivers with regulated flow, and reservoirs: measures for protection against pollution (hydrological regime, study of methods for preparing reservoir beds, processes affecting quality of waters in reservoirs and their protection against pollution).

(3) Hygienic assessment of composition and quality of ground waters: measures for their protection against pollution.

(4) Drinking water standards: particularly with regard to chemical requirements.

(5) Maximum permissible concentrations of noxious substances in sources of water supply into which sewage is discharged.

(6) Utilization of waste waters for agricultural irrigation purposes.

(7) Evaluation of effectiveness of new methods and equipment in the purification and disinfection of drinking-water and of industrial effluents.

(8) Regulations and standards governing the discharge of effluents into rivers.

As regards other fields, it may be worth while mentioning here briefly the investigations being conducted in collaboration with the hygiene research institutions.

The All-Union Research Institute for Water Supply, Sewerage and Hydrological Engineering Equipment (VODGEO) is working on industrial effluent treatment and on the demineralization of waters, and removal of iron. The All-Union Hydrotechnical Research Institute (VNIIGS) is studying settling tanks and suspended matter. The Moscow, Gorki and Novosibirsk Institutes of Engineering Construction are conducting studies into new methods of purifying drinking-water and sewage. The Water Technology and Purification Laboratory of the Ukrainian Academy of Sciences is conducting investigations on drinking-water purification and disinfection. The Academy of Municipal Economy is exploring the theoretical background of drinking-water and sewage purification and disinfection processes with a view to their possible intensification (the Academy of Municipal Economy's filters, contact clarifiers, biocoagulators, bactericidal equipment and so on).

The results of research work are published in the following periodicals: *Hygiene and Sanitation* (*Gigiena i Sanitariya*), *Occupational Health and Hygiene* (*Gigiena Truda i Profzabolevany*), *The Practitioner* (*Vrachebnoye Delo*), *Water-supply and Sanitation* (*Vodosnabzheniye i Sanitarnaya Tekhnika*), *Bulletin of the All-Union Lake and River Fisheries Research Institute*; in collections and works periodically published by research institutes: *Problems of Pollution and Self-purification of Water-supply Sources* (two issues), *Industrial Waste Waters* (collections published in 1948, 1950, 1952, 1954 and 1960), *The Protection of Water-supply Sources against Pollution from Industrial Effluents* (four issues—1949, 1954, 1959 and 1960); and in the *Information Bulletin of the Moscow Institute of Hygiene and Sanitation*, and elsewhere.

CZECHOSLOVAK SOCIALIST REPUBLIC

The Czechoslovak Socialist Republic has a territory of 127 859 km² and a population of 13 474 000. The average density of the population according to the 1959 census is 97 persons per km². This figure is higher than for France and a number of other West European countries. The maximum population density in the Bohemian provinces is 118 per km², and in Slovakia 75 per km². The density varies from province to province as the following figures show:

Prague	216 per km²
Ostrava	203 per km²
Ušti-on-Elbe	160 per km²
Brno	132 per km²
Bratislava	124 per km²
Preshov	51 per km²
High Tatra Territory	35 per km²

Physical features

More than half the country (53%) is situated at a height of between 200 m and 500 m above sea level, and 12% below 200 m. Of the total area of the country 27% is hilly, rising to between 500 and 800 m above sea level. There are plains at less than 200 m along the Rivers Elbe, Morava, Danube, Váh, Lower Hron and Bodrog.

Part of the country is mountainous with peaks rising to between 1000 m and 2000 m, the Šumava Mountains (Bohemian Forest) having an average height of 1387 m, the Krushe Mountains (Erzgebirge) 1244 m, the Jizerske Mountains 1124 m, the Krkonoše 1600 m, the Jesenik Mountains 1492 m, the Beskids 1725 m, the Fatra 1710 m, the Magura 1354 m, the Slovak Ore Mountains 1480 m, the Low Tatras 2045 m, and the High Tatras 2663 m. The lowest point above sea level, 95 m, is in the valley of the Bodrog.

Rainfall and rivers

The average annual rainfall for the period 1900-50 was between 487 mm (Prague) and 850 mm (Banska Bystrica). The maximum rainfall is in May and November, the minimum in February, March and April. In many parts of the country the average annual rainfall is as high as 800 mm. In the mountainous areas from which the rivers take their source the rainfall is as high as 1000-1400 mm a year. The Czechoslovak Republic is comparatively well provided with rivers, which are grouped in the following basins: the Elbe, which flows into the North Sea, the Oder and Vistula flowing into the Baltic, and the Danube flowing into the Black Sea.

The main watershed between the basins of the North Sea and the Black Sea is formed by a plateau known as the Moravian Heights. The predominating directions of flow of the rivers are northwards to the North Sea and southwards to the Black Sea. Some of the rivers, after leaving Czechoslovak territory, flow through the German Democratic Republic and the People's Republics of Poland and Hungary. The highest flow in the rivers is in spring and the lowest in winter. The maximum depth of the rivers is about 2 m.

Table 2 gives the length, area of basin and average annual flow of the more important rivers.

There are 54 reservoirs in the country with a capacity of 1500 million m³, situated on rivers with regulated flow. Five dams have been constructed on the Vltava River, one is under construction and five more are planned. The River Váh has six dams and the construction of reservoirs on rivers is being continued.

TABLE 2
DATA ON THE MORE IMPORTANT RIVERS OF CZECHOSLOVAKIA

Name	Length (km)	Area of basin (km²)	Average annual volume of flow (m³/s)
Vltava	435	28 000	143
Elbe	396	51 000	304
Váh	392	10 600	158
Morava	358	26 000	115
Dyje	303	13 000	40
Hron	289	5 000	58.1
Ohře	250	5 600	37
Berounka	246	8 800	37
Danube (within the boundaries of the CSSR)	161	57 000	2 020

Rivers and reservoirs are being used for domestic and driking-water purposes, for industry, for irrigation and for fish-breeding; 34% of the piped-water supplies are taken from rivers and, in addition, direct use is made of river water for drinking in some villages. The Danube and the lower course of the Vltava and Elbe are used for navigation.

Distribution of population and industry

The total area of the country is 1 278 590 hectares, of which 730 000 (or 57%) are cultivated. The distribution of the population can be seen from the following figures:

Villages or towns with a population of up to :	*Percentage of population*
500	19%
500 - 1 000	16%
1 000 - 2 000	14%
2 000 - 50 000	34%
over 50 000	17%

Czechoslovakia has highly developed industries in which a large proportion of the population—some 30%—are working, while 25% are engaged in agriculture. In country villages and settlements of not more than 500 persons the population is roughly 19%, and the town population 81%.

There are as many as 2000 different industries distributed throughout the country. The chief of these are engineering and metallurgy, the food industry, timber processing, including the cellulose industry, clothing, building materials, and textiles. There are many large plants and factories.

Industry is concentrated in large cities and their surroundings (the towns of Ostrava, Ušti-on-Elbe, Pilsen, Brno, Bratislava, Prague, Kladno and others). Some of the big towns and industries are situated on rivers, including Prague with its population of 980 000 on the Vltava, Bratislava (256 000) on the Danube, and Ušti (66 000) on the Elbe.

Water supplies and sewerage

Piped municipal domestic and drinking-water supplies are operating in 17% of all centres of population and serve 48.1% of the population. All towns have piped-water supplies. Most of these piped domestic and drinking-water supplies are drawn from underground waters (950 000 m³, or about

66%); 490 000 m^3 (about 34%) are drawn from rivers. In addition it is estimated that about 150 000 m^3 (or about 22 litres per person) are drawn daily from wells. Industry, for the most part the food industry, uses 1 300 000 m^3 of ground water daily and agriculture about 96 000 m^3.

The Prague City water supply is fed from river and ground sources, the latter constituting three-fifths of the supply. The rivers Elbe, Vltaba, Ohře, Svratka, Moravice, Dyje and Opava are used as sources of piped domestic and drinking-water supply. Where ground waters are insufficient, the population makes unsupervised use of river water, taking it directly from the river or from filter wells close to the banks.

The domestic and drinking-water supplies in Czechoslovakia are largely drawn from ground waters.

The average daily consumption of water per inhabitant is in the region of 150 litres. In a number of cities this figure is higher: Pilsen, 372 litres; Bratislava, 350 litres; Brno, 268 litres; Prague, 220 litres; Ostrava 200 litres. In the next few years it is intended to raise the average amount supplied per inhabitant to 250 litres daily and to extend the piped-water supply service from the present 48.1% to 56% of the population.

Unfortunately, there is no information on the use of urban water supplies by industry or the railways.

The subterranean waters used for piped-water supplies are not polluted. Iron, manganese, and the carbon-dioxide gases are removed from them before they enter the system, and at some large waterworks they are chlorinated (Prague, Brno).

All cities with upwards of 50 000 population have sewerage systems. The smaller towns have partial sewerage; in all, 7% of the towns and villages throughout the country have sewerage, covering 39.2% of the total population.

The construction of sewerage systems lags somewhat behind that of water-supply services. In centres of population with such systems, the rainfall is led into them, and the sewers usually have storm outlets. Storm waters are passed through sand traps and industrial waste waters in the larger cities are often discharged into the municipal sewers.

There are throughout the country 450 sewage works of various kinds treating between a fifth and a quarter of the total amount of sewage. A plan for the construction of 600 new sewage works has been drawn up and is to be implemented in the near future.

Mechanical, biological and chemical methods of purification are used, domestic sewage usually being treated in horizontal Emscher tanks and biological filters. There are no sewage farms. Waste waters from sugar factories are used for irrigation. The industrial effluents of factories in the past were never subjected to treatment and this situation persists in many cases today. Industrial plant constructed since 1950 as a rule has purification equipment. In a number of large cities (Prague, Pilsen, Gottwaldov, Liberec, Zilina and others) treatment installations are either under construction or will be built in the next few years.

The Central Water Board laid down special conditions and regulations for the discharge of sewage into receiving waters on 27 March 1957 (No. 74). The country's sanitation and epidemiological service is responsible for seeing that these regulations are observed.

Condition of rivers and ground waters

As indicated above, some 20%-25% of the total amount of sewage is at present being treated. Some untreated sewage is discharged into rivers.

The largest quantities of effluents originate from the chemical industry, the production of artificial fabrics, the sulfate-cellulose industry, the coke-chemical industry, and the food industry (sugar factories discharge 60% of the total for the food industry). River pollution from the food industry tends to be seasonal.

Some rivers are severely polluted over certain of their reaches, in which fish and other forms of water life are absent. The following examples can be cited:

On the Elbe, between the towns of Hostinne and Jaromeř for a distance of 38 km: pollution with sulfite waters.

The middle reaches of the same river below the town of Pardubice, for a distance of 16 km, and between Neratovice and Libechov for a distance of 19 km: pollution by chemical industry effluent.

Vltava, upper reaches, between Louhovice to the point of entry of the Lužnice, a distance of 128 km: pollution with sulfite waste waters.

Lower course of Vltava, below Prague, for a distance of 25 km: pollution with city sewage.

Berounka on the reaches below Pilsen, for a distance of 45 km: pollution with city sewage and sulfite waste waters.

Oder, below Ostrava for a distance of 28 km: pollution with heavy industry effluents.

Poprad, between Svit and Velika Lomnice for 8 km: pollution by artificial fabrics industry.

TABLE 3

CLASSIFICATION OF RIVER POLLUTION IN CZECHOSLOVAKIA

Class of river	5-day BOD (mg/l)		Dissolved oxygen (mg/l)		pH		Coli-index	Biological category
	average	max.	average	min.	min.	max.		
I. Absolutely clean	under 1	over 2	over 9	6.5	6.5	8.5	1 000	Beta-oligosaprozoic
II. Clean	1-2	over 3	over 7	6.0	6.5	8.5	10 000	Alpha-oligosaprozoic
III. Permissible	2-3	over 5	over 5	4.0	6.0	9.0	50 000	Beta-mesosaprozoic
IV. Unsatisfactory	3-5	over 7	over 4	3.0	5.0	9.5	200 000	Alpha-mesosaprozoic
V. Very unsatisfactory	over 5	—	under 4	—	—	—	over 200 000	Polysaprozoic

All the rivers of the country have been surveyed and studied from the hygienic standpoint; rivers used by the local population are investigated repeatedly, not less than four times a year. On the basis of these surveys, the rivers have been classified according to their degree of pollution (Table 3).

It can be confidently said that in the coming years river pollution in Czechoslovakia will decrease; measures in this respect have been worked out and confirmed by legislation and by the construction of purification equipment under the State plan.

The most important and extensive ground-water supplies are those of the cretaceous and quaternary deposits. The largest source of ground waters is the Czech cretaceous basin lying in the north-eastern part of Bohemia and spreading south-east. The artesian waters in the cretaceous areas of northern Bohemia are at a depth of about 100 m. The covering of the aquifers is comparatively permeable and their pollution by surface waters is possible. The Palaeozoic ground waters are chemically, for the most part, sulfate waters, with a total solid content of up to 3000 mg/l; waters from the chalk deposits are mainly carbonated with a solid content of 200-700 mg/l; waters from the upper quaternary deposits are also carbonated, with a solid content of up to 400 mg/l.

The ground waters in the southern central area of the country contain large quantities of nitrates of geological origin. To the north of the central part of the country iodine is to be found in the ground waters. Ground waters in the north-western part of the country contain a considerable quantity of fluorine, though, in a number of other parts of the country, the ground-water fluorine content is lower than 0.1 mg/l.

The question of fluoridation of drinking-water is under consideration in these districts. A first experiment in fluoridation is being carried out at the Brno waterworks. Pollution of aquifers has occurred in a number of instances but has been of purely local character, due to the discharge of industrial sewage into absorbing wells. Unfortunately, a number of these still exist in places.

An experiment is being carried out in the replenishment of aquifers by infiltration with river water that has been mechanically purified.

It has already been pointed out that ground water is the main source of piped-water supplies in Czechoslovakia. The population is supplied with water from underground sources as well as from waterworks, and from public as well as from private wells. There is an enormous number of wells in the country. Their depth is usually 5-6 m. As a rule, these wells have concrete-lined shafts and are under the constant supervision of the sanitation and the epidemiological authorities. Well water is regularly examined at the sanitation and epidemiological centres' laboratories. Where pollution is discovered, measures such as the closure, repair and cleaning of the well are enforced.

Authorities and legislation governing pollution prevention

State control over measures for the protection of water resources (surface and underground waters) is vested in the sanitation and epidemiological service and its stations, and in the State Water Conservancy Inspectorate of the Ministry of Agriculture, Forestry and Water Supplies. The rights and duties of these authorities are defined by law under the Sanitation and Epidemiological Services Act (No. 4/1952) and under the Water Supplies Act (No. 11/1955).

Research

Research on the problem of water resources in the broad sense of the word (study of water resources, their protection against pollution, the treatment of effluents, drinking-water standards and so on) is being conducted by a large number of scientific institutes. Of these the following may be mentioned:

1. The Research Institute for Water Supplies, Prague, with its branches in the cities of Bratislava, Brno and Ostrava.
2. The Institutes of Hygiene, Prague and Bratislava.
3. The Institute of Hydrodynamics, Czechoslovak Academy of Sciences, Prague, with branch in Brno.
4. The Central Institute of Geology, Prague, with branch in Bratislava.
5. The Research Institute for Agricultural and Forestry Improvement, Prague and Bratislava.
6. The Fisheries Research Institute, Vodňany.
7. The Department of Hygiene, Charles University, Prague.
8. The Institute of Experimental Medicine, Slovak Academy of Sciences, Bratislava.
9. Faculty of Engineering Construction, Czech School of Technology, Prague.
10. The Schools of Technology at Prague, Brno, Bratislava and other cities.

Research into water-supply problems covers the following main trends:

1. Study of the condition of rivers, the quality of their waters, the conditions under which pollution occurs and the reasons for it; on the basis of this research:

   (*a*) standardized methods of water examination are being worked out;

   (*b*) a classification of rivers according to degree of pollution has been adopted; a river map has been drawn up; standards of drinking-water quality have been established; and directives have been issued for the examination and hygienic assessment of sewage.
2. Systematic study of the ground waters in the Bohemian cretaceous formation.
3. Study of the conditions under which effective water purification can be carried out by clarifiers with suspended layer, and also mechanical treatment of the water with the help of microsieves.
4. Research into the purification of industrial sewage from new industries (mainly chemical) including the purification of phenol effluents.
5. Study of the process of development of water quality in sources of water supply.

The results of research work are published in the following periodicals: *Czechoslovak Hygiene, The Water-Supplies Journal, The Czech Academy of Sciences Water Supplies Journal.* The Water Supply Research Institute (Prague) issues a regular annual bibliographical index of published works.

PEOPLE'S REPUBLIC OF BULGARIA

The People's Republic of Bulgaria has a territory of 111 000 km² and a population of 7 900 000. The average density of the population is 70 per km², which is higher than in a number of other European countries, including Scotland, Yugoslavia, Greece, Spain, Ireland, Sweden and Norway.

Physical features

Half the country is hilly or mountainous, lying between 350 m and 2500 m above sea level. The mountainous districts cover 29% of its territory and considerable areas of this part are afforested. The plains lie between 80 m and 350 m above sea level, along the river valleys of the Danube to the north and the Maritsa and Tundzha to the south.

Rainfall and rivers

The average annual rainfall in the mountainous and hilly areas is from 700 mm to 1200 mm, and in the plains from 550 mm to 650 mm. The heaviest rainfall (67%) occurs in winter and spring; the summer and autumn have appreciably less, the amount in these seasons being in the order of 33% of the yearly average. In some years the country suffers from drought in the summer and autumn.

The biggest rivers are the Danube and the Maritsa. The Danube flows along the northern frontiers of the country for a distance of 470 km. The volume of flow in the river is, on an average, about 5000 m³/s. The Danube is used for industrial water supplies, for agricultural irrigation, and may be used also for domestic water supply. Investigation has shown that the Danube, in its passage through Bulgaria, is comparatively little polluted. It has a number of tributaries on the Bulgarian side: the rivers Iskr, Bit, Yantra and Osat.

The River Iskr flows from south to north and the area of its basin is 8646 km²; the rate of flow at different points of the river is between 0.8 m/s and 1.5 m/s. The depth is from 1.5 m to 6 m. Its tributaries, in turn, are small, swiftly flowing mountain torrents. In the spring floods these streams fill up rapidly and overflow their banks. The River Iskr has a regulated flow, with three reservoirs of capacity ranging between 16 and 670 million m^3, and a depth of between 48 m and 60 m.

One of these reservoirs is used for water supplies for Sofia and for electric power generation. Another serves for industrial water supply and irrigation.

The second tributary of the Danube, the River Yantra, has a basin with an area of 7870 km^2. Its rate of flow is 0.8-1.5 m/s and its tributaries are mountain torrents with the same features as those of the Iskr. There are a number of storage dams on the Yantra and its tributaries, most of them small ones, only one holding more than 220 million m^3. This has a depth of up to 43 m. These reservoirs are used for generating electricity and for irrigation. The smaller Bulgarian tributaries of the Danube, the Bit and the Osat, are not polluted in their upper reaches and are used for water supplies, but their lower reaches are polluted by industrial effluents from the towns of Loveců, Plevň and elsewhere. In their middle reaches both rivers are provided with a large number of small dams used for the irrigation of agricultural crops and for fisheries.

The largest of the interior rivers of Bulgaria is the Maritsa, with a basin within Bulgarian territory of 21 080 km^2. It flows from west to east at a rate of 0.35-1.5 m/s, depending on the season and the reach of the river. There are a number of small reservoirs along the river's course with capacities ranging between 200 000 m^3 and 3-5 million m^3, and 5-12 m deep, and five larger reservoirs with a capacity of 3 million m^3 to 340 million m^3, and depths ranging from 26 m to 54 m. The waters of the Maritsa and its reservoirs are used for generating electricity, for industrial water supply and for irrigation. The waters of the larger reservoirs are of good quality and can be used for drinking-water supply. At the present time, projects are being prepared for piped-water supplies to towns from these reservoirs.

The River Maritsa has two tributaries, the Tundzha and the Arda. The Tundzha, to begin with, flows from west to east, and later turns south. The area of its basin is 7890 km^2, and its rate of flow is 0.8-1.5 m/s. On its upper course a large reservoir is located with a capacity of 92 million m^3 and a depth of 42 m, and a second one is being constructed with a capacity of 350 million m^3 and a depth of 45 m. The water from the reservoir is used for generating electricity, for industrial water supply and for irrigation. The River Arda enters the waters of the Maritsa beyond the frontiers of Bulgaria. It flows from west to east and the area of its basin within the country is 5200 km^2, its rate of flow 1-2 m/s and depth from 0.6-2.5 m. In its middle reaches it has a reservoir of 480 million m^3 with a depth of 55 m, while the construction of a second (380 million m^3, depth 48 m) is now near completion. The water from the reservoir is used for electricity generation, industrial water supply and irrigation.

The River Struma flows from north to south and has a basin of 20 820 m^2 and a rate of flow of 0.8-1.5 m/s. On its upper course there is a reservoir with a capacity of 22 million m^3 and a depth of 42 m. The river and reservoir serve as a source of piped-water supplies for the town of Dmitrovo and its industrial district.

A characteristic feature of the rivers of Bulgaria is that they are very full in spring when the snow thaws and there is abundant rain, but in summer and autumn their waters are low and some of them are even liable to dry up.

Distribution of population and industry

Of the total population, 2 770 000 (35.5%) live in 113 towns. The rest (64.5%) live in rural areas. The biggest city is Sofia with a population of over 500 000, and three cities, Plovdiv, Varna and Ruse have populations of more than 100 000.

The Republic of Bulgaria is a country of mixed industry and agriculture, various types of industry being found in all parts of the country. In the west coal-mining and metallurgy predominate, in the south the chemical and food industries, and in the north the sugar and cement industries.

Most of the more intensively cultivated areas are situated in the river valleys as are the towns: on the banks of the Danube, the towns of Vidin, Lom, Svishtov and others; in the Maritsa basin, Pazardzhik, Plovdiv, Dimitrovgard, Stara Zagora and others; in the Tundzha basin, Kazanluk, Yambol and others; and in the Arda basin, Kurdzhali and Madan. There are no marshlands or deserts.

Water supplies and sewerage

Some 71% of the population are provided with piped domestic and drinking-water supplies, a feature which places Bulgaria in the front ranks of European countries in this respect. All the town population and 62% of the village population have piped-water supplies, 76% of which are from ground sources and 24% from rivers and reservoirs. Out of the 2890 water-supply systems in the country, only 18 take their water exclusively or partly from rivers and reservoirs. Cities and towns that take their water supplies from the upper reaches of mountain rivers or reservoirs are Sofia, Stanke Dimitrov, Kyustendil and Dimitrovo. There is a well-developed network of rural piped-water systems drawing their supplies from springs and headwaters. The standard of the piped water supplied to the population is high and also puts Bulgaria in the front rank in this field.

In small communities 80 litres a day is consumed per inhabitant. In the smaller towns with a population of 10 000-50 000, consumption is 150-200 litres per day, and in cities with a population of over 100 000 it amounts to 250-300 litres per day.

Within the next few years the Sofia city water-supply system will be providing 530 litres per inhabitant. In Varna, after the reconstruction and extension of the waterworks, each inhabitant will be supplied with 600 litres of water.

The ground waters entering the supply systems are as a rule clean and free from pollution. They are not, therefore, treated and only in special cases, after storms or particularly rapid thaws, are ground waters treated by sedimentation or chlorination. On a rough estimate some 850 000 m^3 of water are drawn daily from underground sources for domestic and drinking-water purposes, and some 500 000 m^3 for industry.

Large quantities of water are used for irrigation; to give even an approximate estimate of the quantity is not possible.

Thirty-nine of the larger and some of the smaller of the 113 towns have sewage systems, the proportion of the total population served being 24%. Storm waters enter the sewage systems without prior treatment. Industrial sewage in most cases also enters the municipal sewerage systems. There are no sewage farms or biological treatment plants, the existing sewage purification equipment being mechanical. Plans have been made for the installation of modern purification equipment for the sewerage systems of Sofia, Plovdiv, Varna, Bratsy, Gabrovo and Kurdzhali. Construction of treatment stations will be undertaken within the next few years under the Republic's Plan for Development of the National Economy.

Condition of rivers and ground waters

The condition of rivers and ground water is under constant study by research institutes. The rivers that have received most attention in this connexion are the Maritsa, the Iskr, the Struma and the Yantra. As mentioned above, the rivers of Bulgaria are full in the flood season when the snow is melting and the rainfall heavy; in the summer and autumn they are low and may even dry up. These features condition the hygienic state of the water and its quality, both of which may vary within wide limits. Thus, the amount of suspended matter may be between 0 and 4102 mg/l, including 3662 mg/l of inorganic matter and 440 mg/l of organic matter. The quantity of chlorides may vary between 1.4 and 12.5 mg/l, the sulfates between 2.8 and 25.0 mg/l, the 5-day BOD between 0 and 135 mg/l, turbidity from 40-0.5 cm and lower (Snellen); and the coli-titre 0.1 to 0.000001 cm^3.

The condition of the rivers is most satisfactory in their upper reaches in the mountains or foothills where the population is more scattered and there is considerably less industry. The upper reaches of some rivers such as the Iskr, the Struma, the Rositsa, the Rilskaya, the Osima are used for domestic and drinking-water purposes both directly by the population and through the intermediary of piped-water supply systems.

From the foregoing it is clear that the wide variation in the rate of flow in the rivers and the marked changes in quality of their waters present obstacles to their use by the population. Another situation arises with the construction of large reservoirs, some of which have already become sources of piped-water supplies. There is every basis for extending this practice. Investigation of the condition of the rivers has shown that the main sources of pollution reside in the ever-increasing industrialization.

In the years before the war, when agriculture was the main occupation, the problem of river pollution was never so immediate. Most of the wastes come from the chemical, metallurgical and food industries.

Certain stretches of rivers near industrial districts become heavily polluted when their waters are low in summer and autumn. Thus, the Struma, over a distance of 140 km between Dimitrovo and Blagoevgrad, is polluted by wastes from the coal-mining, food and ferrous metal industries as well as by urban sewage. The River Arda between Rudozam and Studeny Kladenets (110 km) is polluted by wastes from the ore-mining and non-ferrous metal industries.

The River Yantra below Gabrovo is polluted for a distance of 80 km by the textile industry, tanning and urban sewage. The River Iskr between Gara Iskr and Mezdra, a distance of 110 km, is polluted by chemical, engineering and fruit-processing wastes as well as by sewage from the city of Sofia. In these reaches fish disappear during the months when water is low.

No classification of rivers according to pollution has been made. There are regulations, however, governing the discharge of effluents into rivers, but their application in view of the absence of any classification is rather difficult.

From the above it will be seen that underground waters are widely used throughout the country for drinking and industrial water-supplies and for irrigation. It is estimated that the majority of the ground water drawn, at least up to 70% of it, is used for irrigation. In view of the natural conditions and the features of the rivers described above, ground waters at the present time constitute the country's main sources of water supply.

Considerable research has been carried out in the post-war years covering every aspect of the country's water resources. At the present moment the data obtained are being studied and in the near future a detailed hydrological map will be issued together with all pertinent information.

It should be noted that Bulgaria is particularly well off as regards hot springs, with the most varied mineral content. In part, these are used by spas for treatment purposes.

However, these tremendous natural resources remain as a whole unexploited.

The chemical content of the underground waters varies considerably, as the following tabulation shows:

Hardness	6°-35°
Salts	400-1100 mg/l.
Iron	Slight traces to 1.5 mg/l; usually not more than 0.1 mg/l.
Manganese	Traces to 2 mg/l; more frequently less than 0.1 mg/l.
Nitrites	In drinking-water, 0 to less than 0.1 mg/l.
Nitrates	2-10 mg/l.
Fluorine	0.3-1.5 mg/l, and even, in isolated cases, as much as 5 mg/l.
Sulfates	In some waters up to 300 mg/l and more (geological origin).

In view of the extensive use of underground waters and headwaters for drinking purposes they are kept under constant supervision by the sanitary and epidemiological stations. Control includes regular chemical and bacteriological analysis. Experience here has brought to light a number of cases requiring attention because of infiltration of pollutants into ground waters. In brief, ground waters in the villages inevitably become polluted from the surface if they lie at a depth of less than 2 m. Such pollution is unavoidable, even where there are no permeable cesspools.

If the ground water lies at a depth of more than 2 m it may escape pollution from the surface if covered by dense clays or fine-grained soils of mixed sand and clay. With coarse-grained soil, surface pollution infiltrates up to a depth of 15 m.

The most reliable index of ground-water pollution is considered to be the coli-titre. Usually ground waters have a coli-titre of $+10.0\ cm^3$ to $+20.0\ cm^3$. A drop in the coli-titre to $+1.0\ cm^3$ and $+0.1\ cm^3$ means that surface pollution has penetrated. This has been known to occur after rain and the thawing of snow. The present drinking-water standards in force for piped supplies lay down a coli-titre of more than $100\ cm^3$.

Where piped-water supplies from underground sources are installed, the following requirements must be met:

(*a*) Arrangement of a solid clay cut-off 25-40 cm thick around the point at which the water is tapped at a depth of not less than 2 m.

(*b*) Construction at the tapping point of a tank for settling suspended matter.

(*c*) Chlorination equipment: usually chlorination is not carried out, but each water supply must be in a full state of readiness to do so.

The rural population also draws ground water by means of ordinary wells with stone or concrete-lined shafts. Valuable and routine experience has been gained in the chlorination of well water, where necessary with the aid of so-called "cartridge dosers". These are loaded with calcium hypochloride once a month and emit an even, calculated dose of chlorine. Village wells are under the constant supervision of sanitation and epidemiological stations that are empowered to permit or forbid their use. There have been no cases of ground-water pollution from industrial effluents.

The replenishment of ground waters by infiltration through specially made drainage ditches is carried out in the valley of the Yantra, where water is led from the river in open drainage ditches arranged along the banks. As yet the experiment cannot be judged successful. In the first place, infiltration of river water through a thickness of 2-3 m of soil does not give the required results as regards quality; secondly, difficulties have arisen in connexion with the need periodically to make new drainage ditches and to protect them from pollution.

Authorities and legislation governing pollution prevention

Supervision of the implementation of measures to prevent pollution is the task of the State Sanitary Inspection and the Sanitation and Epidemiological Board of the Ministry of Health and Social Welfare (Government Decree of 1951).

There is a network of sanitation and epidemiological stations throughout the country (based on the administrative and territorial divisions) under the authority of the Sanitation and Epidemiological Board. All waterworks and sewerage projects are approved by the State Sanitary Inspection.

Routine sanitary supervision of waterworks and sewerage installations, and supervision of drinking-water and sewage-purification equipment is carried out by the Sanitation and Epidemiological Board and the sanitation and epidemiological stations. State Sanitary Inspectors, and the Chief Medical Officers of the stations have the right to apply sanctions where legislation is not observed, including monetary fines and the closure of the installation.

Research

Research on water hygiene, water supplies, removal of pollution and purification of sewage and protection of the country's water resources is being carried out by sanitation and hygiene research institutes under the Ministry of Health and Social Welfare and under the Industrial Planning and Construction Department of the Council of Ministers' Industrial Committee.

Research has been concentrated on the study of the following main problems:

1. The condition of rivers, causes of their pollution and self-purification processes.
2. The condition and quality of reservoir waters.
3. The composition of, and assessment of the hygienic status of, ground waters and rural water supplies.
4. The composition of industrial effluents, including textile, chemical, food-industry and city sewages.
5. The effectiveness of newly constructed sewage treatment installations.

Work arising from the above research has been printed in the *Proceedings of the Sanitation and Hygiene Research Institute* (vol. 1, 1956; vol. 2, 1957; vol. 3, 1958; vol. 4, 1959); in the *Hydrogeological guide to the rivers of Bulgaria* (vol. 1, 1957 and vol. 2, 1959); and in the following periodicals: *Hygiene (Gigiena)*, *Hydrology (Gidrologiya)*, *Hydrotechnics and Improvement (Gidrotekhnika i Melioratsiya)* published in Sofia.

PEOPLE'S REPUBLIC OF POLAND

The People's Republic of Poland, according to 1959 data, has a territory of 311 700 km^2 and a population of 29 500 000. The average density of population for the whole country is 95 per km^2, a figure considerably higher than that for a number of other European countries, including France, Yugoslavia, Greece, Spain and Ireland.

Physical features

For the most part, the country consists of plains. In the north, on the Baltic coast, there are some small hills and lakes of alluvial origin. In the south there is the fairly low Switokriskiye range about 500-600 m high, and further still to the south the higher Tatra Mountains (1800-2500 m), the Beskids (700-1700 m) and the Sudetes (1100-1600 m).

Rainfall and rivers

The average annual rainfall is about 600 mm, being at its highest from May to July and its lowest between January and March. The highest average annual rainfall is in the Tatras, where it reaches as much as 1000 mm. On the shores of the Baltic Sea the average annual rainfall is between 500 mm and 600 mm.

Relatively speaking, the rivers are not large, the most important being the Vistula, the Oder, the Bug and the Warta. The River Oder rises in Czechoslovakia and runs along the frontier with the German Democratic Republic. The River Bug for parts of its course runs along the frontier with the USSR. All the river courses apart from some small streams rising in the Tatras are in the plains, and the rate of flow is insignificant (0.3-0.6 m/s). The average depth of the rivers is 1.0-1.5 m, though the Oder is somewhat deeper in places (up to 2 m). The seasonal variations in volume of flow are considerable. The River Oder has, in part, a regulated flow; the others have not. Polish rivers are navigable over a total length of 4800 km, though in actual fact only 1080 km are used by shipping.

It seems likely that in the next few years more use will be made of the rivers for shipping and for the generation of electricity. This might well involve changes in their hydrological regime and sanitary conditions. The majority of rivers are used by the towns and cities situated on them as sources of piped-water supply.

Country villages on the banks of rivers also draw their domestic and drinking water from them, either directly or from filtration wells close to the banks.

Distribution of population and industry

The urban population amounts to 14 000 000, or 47% of the total, and the rural population to 15 500 000, or 53%. Data supplied by the Central Statistics Office give the number of towns as 742, including 9 towns with a population of over 200 000, 13 towns with a population of 100 000-200 000, 19 towns with a population of 50 000-100 000, and 701 towns with a population under 50 000. The population of Warsaw is 1 095 400.

The People's Republic of Poland is a country of mixed agriculture and industry. Information available in 1950 showed that 47.1% of the population was engaged in agriculture. Some 65% of the country's territory is cultivable and 24% is under forest. In the province of Katowice there is a considerable industry and the population density is as high as 342 per km^2. The larger cities (Warsaw, Cracow, Poznan, Łodz, Stettin, Gdańsk and others) are also industrial centres. The towns of Gdynia, Gdańsk and Stettin are on the shores of the Baltic, and most large towns on the banks of rivers: Warsaw and Cracow on the Vistula, Poznan on the Warta, Wrocław on the Oder. These cities have a total population of 2 500 000 (about 8% of the country's population and 18% of its urban population). The city of Łodz lies on the watershed between the Vistula and the Pilitsa.

Water supplies and sewerage

During the Second World War many Polish cities were destroyed and the urban water-supply and sewerage services suffered considerably.

With few exceptions there are municipal water-supply services in all towns, in most cases (90%) drawing on underground water. A minority of towns use surface waters for their supply. In the Warsaw district some 35 small towns have municipal supply systems drawing on ground waters. In a number of cases these are treated, the iron, manganese and hydrogen sulfide being removed and the colour improved. The quality of the supply is carefully controlled from the bacteriological standpoint and corresponds to generally accepted standards. On an average the consumption is about 220 litres daily among town dwellers.

It should be noted that industrial undertakings sited in the towns use 50% of the water provided by the municipal services.

The majority of towns have a sewerage system, though its development in the post-war restoration period has lagged somewhat behind in comparison with water supplies. The proportion of sewage subject to treatment is 34%. Storm and thaw waters enter the municipal sewers without prior treatment. Industrial waste waters, too, in most cases enter the town sewers, and where purification installations exist are treated by these together with the other sewage.

Sewage treatment is usually effected in Emscher-type tanks, in biological filters and sewage farms. Several cities employ the latter system. Treatment installations have for the most part been constructed since the war: not all sewerage systems, however, have such installations, and discharge of untreated sewage into the rivers does consequently take place. Under the State plan the construction of treatment plants is to be intensified in the next few years and the sewerage system is to be increased by 21.4% in towns and at factories whose effluents cannot be accepted in the municipal sewers. An increase of 16.6% is planned in the water-supply services. In rural districts there are no piped-water supplies or sewerage, and the overwhelming majority of the population there (some 80%) makes use of ground waters from wells. Villages situated on river banks make direct use of the river water without control.

Condition of rivers and ground waters

In a number of cases the country's rivers are polluted by domestic and industrial sewage. The most polluted sections are those lying downstream from cities and industrial districts. The length of such sections is from 30 km to 50 km and more. In these polluted reaches the river water cannot well be used for drinking or other purposes. The worst pollution in rivers, as regards both quantity and quality, is caused by the untreated wastes from the following types of industry: mining, chemicals and dyes, artificial fabrics, cellulose, plastics, soda, fruit and sugar industries, yeast preparation, manufacture of starch, breweries and slaughterhouses. Of the total number of rivers in the country, 10% are regarded as sewage-polluted, with extensive deleterious effects on the smaller rivers such as the Charna Przmca (domestic sewage and mining wastes), the River Pisia (untreated waste-waters from the textile industry and domestic sewage), the River Utrata (domestic sewage and effluents from the cellulose industry). In these small rivers the fish are dying out.

In recent years the Institute of Hygiene and the sanitation and epidemiological stations have carefully studied the condition of one-third of the rivers of the country. Survey of the rest is continuing. At the same time the sanitation and epidemiological stations annually conduct repeated investigations into the causes of changes in the condition of the rivers under study. Thus they always have at their disposal evidence of the type of river pollution involved. The investigations carried out have made it possible for the State sanitary authorities to plan and implement measures on a scientific basis to prevent pollution along the following lines:

(*a*) Classification of rivers according to degree of pollution;

(*b*) Expert evaluation of newly-constructed water-supply and sewerage systems in the light of the river classification;

(*c*) Establishment of sanitary requirements regarding the discharge of sewage into rivers, confirmed by Government decision No. 668/55 of 20 August 1959;

(*d*) Establishment in conjunction with the Central Water Supply Board of a project for the reclassification of rivers on a more accurate basis, specifying standards for the purification and discharge of sewage into rivers.

The research carried out by the Institute of Hygiene and the work done by the State sanitary authorities have checked the further pollution of water-supply sources and have done much towards promoting a rapid extension of the treatment installations under the State Construction Plan for the coming years.

It has been mentioned that some 80% of the rural population uses ground waters for drinking and other domestic requirements. In addition to this, many municipalities draw their waters from the ground. Thus ground waters in the People's Republic of Poland occupy first place as a source of drinking-water supply.

The chemical composition of the ground waters in different parts of the country and in different geological conditions can be summed up as follows:

Hardness	1° - 50°
Salts	100 - 1000 mg/l
Iron	0 - 10 mg/l
Manganese	0 - 2 mg/l
Nitrates	0 - 30 mg/l
Chlorides	5 - 400 mg/l
Fluorine	0.1 - 0.5 mg/l

Near the shores of the Baltic the waters have a high content in salts. In two regions (round Poznan and Wrocław) the deliberate replenishment of ground waters from surface sources by infiltration has been practised. Surface waters in this case are not subjected to treatment. Instances of pollution of the ground water as a result have not been observed. Ground waters in the upper aquifers under unfavourable conditions are polluted by organic substances that penetrate from the polluted surface and soil together with storm waters. Such pollution has been observed in rural areas. Sanitation and epidemiological stations constantly supervise the village wells, the water being regularly subjected to laboratory analysis, and are empowered to close wells found to have polluted water. Pollution of the deeper aquifers has been observed in isolated cases of local significance only. Thus, in the Stalova Volya district a metallurgical combine polluted the subterranean waters with iron by discharging to the soil effluent from its etching and galvanizing shops. In the neighbourhood of Kelcy the artesian sources in the chalk deposits were polluted by organic substances that had penetrated with storm waters from the surface soil through fissures in the chalk deposits.

In the north-west of the Mazovec depression and in the Gorno-Schlenc industrial district cases have occurred of ground waters becoming mineralized by forced pumping, chemically polluted water having penetrated from neighbouring districts. The protection of subterranean waters from pollution is the responsibility of the State Sanitary Inspection and the sanitation and epidemiological stations, which have appropriate powers as indicated above.

Authorities and legislation governing pollution prevention

There are two types of authority in Poland responsible for the implementation of measures against surface- and ground-water pollution. These are the State Sanitary Inspection under the Ministry of Health and the Department of Water Supply Protection under the Central Water Supply Board, which is directly under the Council of Ministers. The State Sanitary Inspection was set up by government decree in 1954.

The Central Water Supply Board was set up by government ordinance in 1960. The State Sanitary

Inspection has services based on the administrative divisions, in the form of sanitation and epidemiological stations throughout the country.

The Central Water Supply Board, in its turn, has a country-wide network of laboratories. The State Sanitary Inspection and its sanitation and epidemiological stations are responsible for official supervision of the condition of surface and underground waters. The State Sanitary Inspection has powers of decision on all water-supply projects and sewerage installations, on the discharge of sewage into rivers and the extent of its treatment, and can establish regulations and standards in these matters. The State Sanitary Inspection and sanitation and epidemiological stations make a systematic study of the condition, content and quality of surface and subterranean waters, regularly analyse them, study the composition of domestic and industrial sewages, and maintain, by laboratory analysis, constant supervision over the effectiveness of waterworks and sewage treatment installations.

The decisions and proposals of the State Sanitary Inspection and its subordinate authorities on water-supply and sewerage problems, including the discharge of sewage into rivers, are binding.

Where the organizations and departments concerned are not in agreement with the proposals made by the State Sanitary Inspection they can make objection to the Government authorities.

The State Sanitary Inspection and sanitation and epidemiological stations have the power to inflict fines on persons and bodies responsible for contravention of the sanitary standards laid down.

The Hygiene Research Institute at Warsaw, and its branches in the provinces, work under the State Sanitary Inspection. These research centres assist the State Sanitary Inspection in regular annual surveys of the condition of surface and underground waters. The sanitation and epidemiological stations take part in this work.

The Department of Water Supply Protection of the Central Water Supply Board is responsible for the study of all aspects of the country's water resources with a view to their appropriate exploitation in the interests of the national economy. At the same time, the Department is responsible for seeing that measures for the prevention of pollution are implemented.

In all its work this department and its services maintain close contact with the State Sanitary Inspection and the sanitation and epidemiological stations. They make joint decisions on problems concerning surface and ground-water pollution.

A classification system for rivers worked out by the State Sanitary Inspection is in use, but this authority, jointly with the Department of Water Supply Protection, has now worked out a new classification project which has been submitted to the Government.

The problem of water resources (including the pollution of surface and subterranean waters, the treatment of sewage, purification of drinking-water and methods of protection of water supplies from pollution) is being studied by a number of institutions, the chief among them being:

1. The State Institute of Hygiene with the assistance of town sanitation and epidemiological stations.
2. The Institute of Municipal Economy.
3. The Department of Water-Supply Protection.
4. The Institute of Water-Supply of the Central Water-Supply Board.
5. The sanitary engineering faculties of the Warsaw, Wrocław and Silesian Polytechnical Institutes.
6. The Institute of Chemistry (Ministry for Chemical Industry).
7. The State Hydro-Meteorological Institute.

The results of research are published regularly in the following publications: *Yearbook of the State Institute of Hygiene; Gas, Water and Sanitation*, and *Water Supplies*.

PEOPLE'S REPUBLIC OF ROMANIA

The population of the Republic is 18 058 604 and its area 237 500 km², giving an average population density of 76 per km². There are areas of greater density, as, for example, the province of Ploeşti (106 per km²), the province of Bucharest (85 per km²), and the province of Craiova (75 per km²). In a number of other provinces, such as Constanţa, the density is much lower than the average, being 40 per km². The average density of population in Romania is the same as that of France, and greater than in many West European countries such as Scotland, Yugoslavia, Greece, Ireland and Spain.

Physical features

The territory of Romania varies considerably in altitude, with plains lying 100-200 m above sea-level, hilly areas with plateaux 300-500 m above sea-level, and mountains rising to 2500 m. The plains are agriculturally exploited for cereal and vegetable crops, the hilly regions and plateaux are used for fruit growing and cereals, and the mountainous regions are under forest.

The larger part of the territory (61 %) is under cereal crops, 27 % consists of forest and about 2 % is comprised of lakes and areas subject to flooding.

Rainfall and rivers

The climate of Romania is temperate and continental with an average rainfall in the plains of 400 mm, rising to 1200 mm in the mountain areas. Most of the rain falls in April, May and June, the dry months being August, September and October.

The biggest river is the Danube with a course, within Romania, of 1000 km. Into it fall all the other rivers except for a few that flow into neighbouring countries.

The Danube enters Romania from Yugoslav territory and out of the 27 more important rivers, ranging in length from 127 km to 770 km, 20 have their course entirely within Romania. Their volume of flow varies remarkably, depending on the rainfall. In the mountainous areas there is no permanent accumulation of snow that can exert any regulatory influence.

The average minimum volume of flow of the different rivers is between 1.5 m^3/s and 69 m^3/s. The rate of flow varies between 0.4 m/s and 1.2 m/s. The rivers are used for domestic and drinking-water supplies indirectly by means of piped-water systems, and by unorganized direct use, as well as for supplies to industry, agricultural irrigation, the generation of electricity and fisheries.

Distribution of population and industry

Of the total population 31.7 % is urban and 68.3 % rural. The largest town is the capital, Bucharest, with a population of 1 297 000. Of the other towns there are 10 with a population over 100 000, 5 with a population of 50 000-100 000, 25 with a population of 20 000-50 000, 41 with a population of 10 000-20 000, and 23 with a population of 5000-10 000.

All the towns are situated on the banks of rivers or in close proximity to them. The town of Constanţa, with a population of over 100 000, is on the shores of the Black Sea.

Industry is more or less evenly distributed throughout the country. A number of provinces—Ploeşti, Hunedoara, Stalin, Timişoara, and Baia Mare—are more industrialized than the rest.

Water supplies and sewerage

Urban amenities suffered severely as a result of the Second World War. In the post-war years great efforts have been made and much money invested in the construction of urban water-supply and sewerage systems.

In towns that have sprung up in the past ten years (Onesti, Nevodari, Victoria, Petru-Groza and others) up to 100 % of the population have piped-water supplies while 90 % of their population are served by sewers. The figures vary from town to town.

In the older towns 50 %-75 % of the population are provided with piped-water supplies and 38 %-45 % with sewers. The majority of the towns take their piped-water supplies from rivers, about 20 % of the urban population being supplied from underground sources. Water from the latter is of good quality and enters the supply system without prior treatment. Only a few supply systems—those of Suceava, Satu-Mare and Timişoara—have equipment for removal of iron and manganese from ground waters. Supply systems that draw their water from rivers have purification equipment for sedimentation and filtration. All waterworks have apparatus for chlorination which can be used in case of need. Industry makes use of 25 %-45 % of urban water supplies. Under the State plan for the next five years a large number of water supply installations are to be built and the water-mains network in towns and villages is to be extended by 1700 km.

Various methods are employed for the purification of sewage. In two towns, Oradea and Arad, there are sewage farms, giving good results in the treatment of town sewage. At present the problem of using Bucharest sewage for the irrigation of agricultural lands in the neighbourhood of the city is under study. The mechanical treatment of sewage in Emscher-type sedimentation ponds is applied in a number of towns.

In many cases industrial waste waters enter the general town sewerage system. Storm waters, whether from rain or thawing snow, also usually enter the municipal sewerage system. In towns situated in mountainous districts storm waters are diverted directly into rivers by means of storm conduits. In neither case are storm waters given prior treatment.

Equipment for the treatment of domestic and industrial sewage of cities and plants that have none are to be constructed under the State plan in the next five years.

Condition of rivers and ground waters

The Bucharest Institute of Hygiene and Health and the sanitation and epidemiological stations organized throughout the country in the post-war period are making a systematic study of river conditions and of the composition of domestic and industrial sewages. They exercise constant control over the quality of piped-water supplies and over the effectiveness of water treatment installations. Their work has disclosed that certain stretches on some rivers are polluted by domestic and industrial sewage. This occurs, for example, in the Lepuş and the Sesar due to effluents discharged by the ferrous metal industry, on the River Cherna from phenol effluents, on the River Birsa from industrial sewage containing bisulfite liquors, and on the Dymbul from oil products. The River Dambovnic below Bucharest and the River Baklui below Iaşi are badly polluted by town sewage.

Surveys of the condition of the different rivers have enabled them to be classified into three different categories. In the first come those reaches of rivers utilized for piped-water supplies; in the second, reaches which it is possible to use for unorganized direct water supply; and in the third, rivers flowing through inhabited areas that can be used for bathing and fisheries.

The pollution indices on which these categories are based are: suspended matter, odour and taste, dissolved oxygen, 5-day BOD, colour, pH, absence of pathogenic micro-organisms, absence of toxic substances and of indissoluble floating substances.

The country's ground waters have also been systematically studied since the war. Wells and springs used by the local population through the intermediary of a piped-water supply system, or directly, are under the constant supervision of the sanitation and epidemiological stations; the laboratories of the latter carry out chemical analyses and bacteriological tests of well and headwaters regularly, and additionally as need arises.

The most important sources of ground water are in the quaternary deposits (gravels and sands) of the Beregan plain, in southern Moldova and in the lime formation of the Dobruja. There are extensive areas with well-protected artesian aquifers in the Banat plain and southern Moldova. In recent years the practice of utilizing underflow water sources has been increasingly adopted.

There are a large number of mineral-water sources with a high mineral content in various parts of the country.

Some 98%-99% of the rural population use ground water from springs and wells (about 800 000 wells). Ground waters as a rule are not used for irrigation. In most cases their chemical composition satisfies generally accepted standards of hygiene. In certain districts (the Dobruja and the Transylvanian Plateau) the ground waters have a high degree of hardness amounting to over 20° (German hardness). In some still smaller areas (the northern part of Moldova and the Banat plain) there are ground waters with an iron and manganese content of over 0.5 mg/l. In the Danube valley (Beregan), in Northern Moldova and on the Transylvanian Plateau the ground waters have a high content in sulfates (400-1000 mg/l) and chlorides (20-40 mg/l). The fluorine in underground waters is usually less than 1 mg/l except in three districts, where its content is over 1 mg/l. An experiment in fluoridation is now being carried on at the Targu Mureş waterworks.

Ground waters throughout the country have remained clean and unpolluted. Only in isolated instances has pollution of the upper aquifers by oil been observed in oil-producing districts as a result of surface soil pollution.

Authorities and legislation governing pollution prevention

The authorities responsible for seeing that measures for the prevention of surface-water and ground-water pollution are implemented are the Sanitation and Epidemiological Board of the Ministry of Health and Social Welfare, and the State Water Supplies Committee under the Council of Ministers. The Sanitation and Epidemiological Board controls the sanitation and epidemiological services throughout the country.

The State Water Supplies Committee deals with water conservation problems from the standpoint of the national economy; the sanitation and epidemiological authorities carry out official supervision from the standpoint of hygiene and the prevention of surface- and ground-water pollution. These authorities are empowered by legislation to forbid the discharge of untreated effluents into rivers and can inflict fines on bodies and enterprises that do not fulfil the requirements of the sanitation and epidemiological services.

The following legal measures have been adopted for the protection of water resources against pollution:

1. Ordinance of the Council of Ministers No. 608/1952, on the establishment of protective zones for

water-supply sources and on drinking-water supply installations.

2. State Standard No. 4706/1955, on conditions of discharge of effluents into rivers.

3. Ordinance of the Council of Ministers No. 769/1957, on standards for the planning and distribution of industrial enterprises, covering also requirements for the discharge of industrial effluents.

Research

Research on the country's resources and their protection from pollution is being carried out by the Institute of Hygiene and Health of the People's Republic of Romania and by the Hydrotechnical Research Institute. The results of this research have provided the basis for the above legislation, for the classification of rivers into three categories, and also for the drafting and publication of standards and directives on water hygiene and supply. The results of this research are printed in the periodical *Hygiene*, published in Bucharest; in the *Proceedings of the Scientific Session of the Institute of Hygiene and Health*, 1955, Bucharest; in *Work and Research in the Field of Hygiene*, 1960, Bucharest (Symposium on Methodological and Documentary Material from the Bucharest Institute of Hygiene and Health of the Romanian People's Republic); and in *Jubilee Scientific Session of the Cluj Institute of Hygiene*, 1960.

CONCLUSION

On the basis of the material outlined in this report, the following main points related to the problems under study are suggested for further consideration.

1. The problem of protecting surface and ground waters from pollution cannot be investigated and solved in isolation from a whole series of matters of principle concerning the condition and utilization of a country's water resources. Consequently, we can only speak of a single problem embracing every aspect and trend of study and activity relating to the condition, utilization and protection of the country's water resources against pollution.

This problem is one of utmost importance for the State, affecting as it does so closely its general plan of economic and industrial development. Matters of principle relating to this problem can be decided only by the State itself; among these matters of principle are national legislation on the utilization of water resources, on standards of drinking-water, on standards and regulations for the discharge of effluents into receiving waters, on methods and arrangements for financing the construction of sewage treatment installations and for the supervision of such construction, on control over the effective operation of sewage treatment installations, on supervision of the condition of surface and ground waters, and on the executive and legal authorities responsible for implementing the measures to protect water resources against pollution.

2. Experience in the USSR, Czechoslovakia, Romania and Poland, which have set up special State authorities to deal with their country's water resources, deserves attention, in particular as regards the following:

(*a*) USSR: The Water Resources Department of the USSR State Planning Committee (Gosplan) and Departments of Water-Supply Planning in the State Planning Commissions of the Union Republics. In the Water Resources Department of Gosplan, the following tasks have been set: regulation, co-ordinated use and protection of the country's water resources; establishment of the main principles of the water economy and planned development of water resources in conjunction with the plan for the development of the national economy, and co-ordination of all water-supply activities that are of joint concern to the Union Republics and to neighbouring States.

(*b*) Czechoslovakia: The State Water Supply Inspection of the Ministry of Agriculture, Forestry and Water-Supplies.

(*c*) Romania: the State Water Supplies Committee under the Council of Ministers.

(*d*) Poland: the Central Water Supply Board under the Council of Ministers.

3. The essence of the concept " river pollution " should be defined once and for all. Key has written:

> " A river is to be considered polluted when the water in it is altered in composition or condition, directly or indirectly as a result of the activities of man, so that it is less suitable for any or all of the purposes for which it would be suitable in its natural state." [1]

This statement can be taken as correct and as the basis of our conception of " river pollution ".

In the same way, what is meant by " the utilization of river water " ought to be more clearly defined.

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[1] Key, A. (1956) *Bull. Wld Hlth Org.*, **14**, 845.

4. The experience of the USSR, Czechoslovakia, Poland, and the Republic of Romania in classifying rivers in accordance with their utilization might usefully serve as a basis for rules for the discharge of effluents.

5. The experience of the USSR in the scientific establishment of maximum permissible concentrations of noxious substances discharged with sewage into sources of water supply merits consideration.

6. It would be valuable to organize a series of highly specialized working conferences (for hygienists, sanitary engineers and representatives of health authorities and services etc.) for the purpose of:

(*a*) mutual exchange of experience in the solution of specific practical aspects of the problem of protecting water resources from pollution in different countries (such problems as legislation, classification of rivers, rules for discharge of effluents into receiving waters, the latest methods of treating effluents, supervision of the construction of purification equipment and of the effectiveness of their work, etc.);

(*b*) the establishment of generally accepted agreements on the questions under discussion;

(*c*) establishment of agreed research activities and sanitary measures.

RÉSUMÉ

L'auteur expose les mesures prises par les Gouvernements de l'URSS, de la République socialiste de Tchécoslovaquie, des Républiques populaires de Pologne, de Bulgarie et de Roumanie, afin de protéger les cours d'eau de la pollution. Chacun de ces pays a mis sur pied un organisme, dont le fonctionnement est décrit, chargé de la question des ressources en eau et de leur protection. Pour chaque pays sont indiquées les conditions géophysiques et hydrographiques, la répartition de la population et des industries. La protection des cours d'eau est en relation étroite avec le plan général de développement industriel et économique, et, de ce fait, il incombe à l'Etat de s'en occuper, à divers points de vue: législation applicable à l'ensemble du pays sur l'utilisation des cours d'eau, normes de l'eau de boisson, évacuation des eaux usées dans les rivières, construction et financement des stations d'épuration, surveillance des eaux quant à leur salubrité, et délégation des responsabilités à des organismes exécutifs chargés de la protection des eaux contre la pollution. L'auteur souligne en particulier la nécessité d'organiser des conférences de travail à un niveau élevé de spécialisation, pour hygiénistes, ingénieurs sanitaires et administrateurs de la santé publique de différents pays, afin que soient établies en commun les méthodes de protection des eaux contre la pollution, sous leurs divers aspects: législation, classification des rivières selon leur usage, réglementation de l'évacuation des eaux usées dans les rivières, techniques les plus récentes de traitement des effluents, surveillance de la construction des usines d'épuration, recherches à entreprendre, et mesures sanitaires à appliquer.