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THE EFFECT OF URBANIZATION ON THE HYDROLOGICAL SYSTEM AND WATER QUALITY. CO-OPERATION OF CENTRAL AND EAST EUROPEAN COUNTRIES UNDER THE IHP UNESCO

The problem of the effect of urbanization on water relations has recently come to be the subject of international co-operation. In 1970, a working-group of the International Hydrological Decade (IHD) undertook the assessment of the knowledge to the problem in the world. Soon, a draft report was ready which, upon the initiative of Mr M. B. McPhearson, the head of the group, served as a basis for the discussion at the International Workshop on the Hydrological Effect of Urbanization held in Warsaw on 8—10 November, 1973. The meeting turned to be important for a proper formulation of the problem and for outlining further work in this field, which was later undertaken, as one of the priorities, under the UNESCO International Hydrological Programme (IHP). The report on the hydrological effect of urbanization was published by the UNESCO (Hydrological Effects, 1974).

The IHP National Committees of Central and East European countries undertook these topica in 1977 by launching a research theme entitled "The quantity assessment of man's impact on water resources and hydrological cycle" co-ordinated by the IHP National Committee of the USSR. Within several years of co-operation, a joint report was elaborated in which one chapter dealt with the role of urbanization and water demand by industry and urban economy in the transformation of water resources and hydrological cycle. This was the first assesment of the problem in those countries. Following the discussion at the successive meetings of the IHP national committess of the Central and East European countries in the years 1980—82, it was decided to undertake a more profound research i.a. on the effect of urbanization on the hydrological system and water quality. A working-group co-ordinated by Poland, was established, which held its first meeting in Poland on 11—16 July, 1983. The group adopted the programme of research for the years 1983—1989. The preliminary stage of the work (1983—1984) envisaged the elaboration of country reports on the state of research and research

needs and the proposal concerning the research objects of detailed studies was adopted. In the second phase of the programme (1984—1986) the resarch work was to be developed on the effect of urbanization on the hydrological system and water quality in the domain of transformation of:

— surface hydrographic network and level of groundwater;
— elements of water balance (precipitation, evaporation, surface and underground storage, surface and underground run-off);
— water quality and circulation of solid matter.

The third stage of the programme (1986—1987) was devoted to the elaboration of a methodological guide, which would be a contribution to IHP-III, presented at the international seminar held in 1988. Stage four 1988—1989) was to be focused on research on prospects as a continuation of stage II, particularly experimental resarch and conception of mathematical models of the effect of urbanization on the hydrological system and water quality.

The researches on urban hydrology carried out so far in various countries are usually concentrated on water management in towns and urban hydraulics. Thus it seems that the term "urban hydrology" is not properly used in this context. Researches undertaken by Central and East European countries are mainly aimed at the assessment of changes in water circulation in urban areas, as well as transformation of hydragraphic network nad water quality.

THE ASSESSMENT OF URBANIZATION ON THE HYDROLOGICAL SYSTEM AND WATER QUALITY

The methodological manual on the assessment of the effect of urbanization on the hydrological system and water quality, elaborated by the working-group of Central and East European countries under the IHP, is the first work of that kind in hydrological literature. It is a collective work edited by V. V. Kuprianov USSR, Z. Mikulski, Poland.

The first chapter of the manual deal with two main notions, namely urban area and the hydrology of urbanizing territory. An urban area is the area which the dominant factors of anthropogenic transformation are the industrialization and urbanization. The urban area is characterized by:

— large concentration of people on a relatively small area;
— large concentration of various industrial activities, and;
— large share of anthropogenically transformed area in comparison with the natural areas.

The term of the hydrology of urbanizing territory is closely connected with a growing degree of urbanization in the world. The number of the world population living in towns has been rapidly increasing. Whereas in the late 19th century it hardly made up 10%, towards the end of this century it is likely to amount to 50%. As Kuprfianov (977) rightly points out, in studies on the natural water circulation any empirical formulae have always included parameters donoting the effect of the various elements of the environment, i.e. the share of lakes, swamps and forests in the area of the basin. Today the researchers begin to appreciate changes caused by the rise of urban and industrial areas and the accompanying road transportation. Urbanization and industrialization constitute an important aspect of the anthropogenic impact on water relations, which is reflected in the two main trends:

(1) land management, changes in its relief and conditions of local water circulation;

(2) provision of additional large quantities of water to the city and its industry as well as the treatment of similar quantities of urban and industrial sewage. Regardless of quality changes (in water circulation) there occur more and more serious quantity changes (in solid matter circulation). The effects of man's activity has been called "anthropopressure".

The urban and industrial area is marked by a dense land development, occupying new territories lying within its range for settlement, and establishing suburban settlements. The effect of such settlement is the increasing impermeable are such as roofs streets, markets etc. As a result, the hydrological cycle undergoes major transformation being an effect of changes of the particular components of water balance. Let us discuss them successively:

(a) atmospheric precipitation may increase as a result of the city's growing air pollution as well as a certain disturbance in the flow of air masses caused by a high building structures, either urban or industrial;

(b) areal avaporation increases due to higher temperature in the city and the warming up of impermeable surfaces. This primarily concerns the intensity of evaporation but not its sum, which is limited by the volume of evaporating water within the city;

(c) infiltration considerably decreases due to the occurrence of impermeable surfaces. As a rule, it is only the parks, gardens and school playgrounds (the so-called infiltration windows) that permit the infiltration process, whereas a compact settlement of the city's centre makes it almost impossible. Thus the groundwater level stays much lower when compared with an open area. This sometimes is also due to a con-

siderable individual water consumption by the local economy or even industry. The low level of groundwater is also due to building requirements (draining of building area);

(d) run-off from the area of the urban and industrial complex undergoes basic transformation. A minimum groundwater run-off is accompanied by the growing surface runoff, which is usually directed underground through the sewage system (storm sewer network). This applies to the heavy precipitation and snow melt runoff. Thus the flood wave height from the area of the urban and industrial complex may increase several times;

(e) changes in the hydrographic network as the effect of local water circulation. The land settlement and the rise of the drainage sewage system cause the decrease and even disappearance of natural water-courses and other open water basins. This is usually the final effect of changes in the hydrological cycle within an urban and industrial complex.

The urban and industrial complex needs large quantities of water both for city and industrial requirements that usually exceed the volume of local water resources, either surface or underground. Thus the need arises to transport water from other regions, construct storage basins and other hydrotechnical facilities. Within a relatively small area, a large amount of water is concentrated, which is stored in various tanks and water basins or is simply pumped into the water-supply system after its treatment. The water balance of the area is considerably changed: the positive side of the balance is supplemented with the volume of water "imported" into the complex.

Enormous water requirements of the urban and industrial complex cause the rise of similar quantities of urban and industrial sewage which must be removed to be neutralized and utilized. This usually requires the preparation of a vast area for the building of the so-called settling tanks and facilities for sewage treatment (mechanical, biological or chemical). This may lead to further changes in the local water circulation and, first of all, favours the pollution of water resources and deterioration of their quality within the urban complex.

Chapter two comprises methods of the assessment of territorial changes of hydrographic objects using cartography photo-interpretation and satellite data. The analysis is made of the methods of research on the disappearance of water-courses and small water basins, particularly in areas of subterranean mining and quarries. It was found out that there were possibilities of the appearance of new basins following the rise in the number of the post-mining pits (lignite mining, stone and gravel exploitation etc.). Emphasis was put on the settlement of water-courses,

construction of canals and transportation of water, including the carrying away of polluted waters from the mines. Stress was also laid on the phenomenon of the decreasing level of groundwater and the rise of depression cones. Finally, frequent changes of surface and underground watersheds in urban areas were reported.

Chapter three is devoted to the hydrological cycle in urban areas, and particularly its changes and their evaluation. Emphasis was put on the acquisition of basic data, storing and processing of data from measurements and observations, as well as evaluating their reliability and precision. The main stress was laid on methods of the assessment of changes of the elements of the hydrological cycle. Changes in volume and spatial distribution of the atmospheric precipitation were discussed, including the correction of the results of measurements. Much attention was focused on the transformed evaporation process, as evaporation is sometimes forced and becomes the so-called technological evaporation (in some industrial plants). In the area of settlement, there ocurs a significant change of infiltration it is being done only through the above--mentioned infiltration windows. Infiltration is closely connected with the problem of storage of which the volume is small and highly limited. The mutual relationship between the surface and underground runoff completely changes in favour of the former; it is being done through underground drainage (storm water drainage) As a result, flood wave sometimes considerably increases. On the other hand, groundwater recharging is considerably decreased. In effect, changes in components of the hydrological cycle lead to the anthropogenic changes of water balance, which is often additionally transformed due to the provision of extra volume of water to the urban area for the city's and industrial needs.

Changes in the yearly and seasonal flow as well as in the transportation of the solid matter are discussed in Chapter four. An intensive management of rivers within urban areas causes considerable changes in transporatbility of the suspended and bed load sediments. The volume of this transport increases due to the flow of debris from the city. On the other hand the bed load is often dredged for building, which disturbs the city etc.

Chapter five of the manual is devoted to changes in the quality of surface and underground waters, and especially to methods of water quality assessment. First of all, forms of changes in water quality (hydromorphological, hydrological and chemical and biological) were discussed; next the assessment of water quality (methods of balance of chemical compunds and methods of analogy) was made. Attention was also focused on the thermal contamination and on the so-called catego-

rization of water purity adopted in various countries.

The concept of methodologcal manual was presented by the author of this paper on International Symposium on Hydrological Processes and Water Management in Urban Areas (Urban Water '88) in Duisburg in April 1988. It has met with a great interest and acknowledgment of the symposium's participants. It will issue in Russian in 1991.

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