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Preface

Central and Eastern European countries face serious environmental problems. Their management depends on the type of pollution. The restructuring of economies creates opportunities to effectively control industrial and agricultural discharges by introducing clean technologies. Urban pollution forms quite a different category as, stemming from the low development of existing infrastructure, investment cost requirements are enormous. The paper outlines the present situation and discusses some of the elements of future policies including economic instruments, and alternative and innovative technologies.

Abstract

The paper discusses past development and present state of urban water resources systems in Central and Eastern Europe which are far from the level of Western countries. High utility loops contribute significantly to often serious contamination of receiving waters. Capital costs of extending the existing capacities of urban water infrastructures are enormous. The management of urban pollutions requires careful planning on the basis of setting national priorities and international ones for shared water resources. The role of systematically prepared laws and environmental legislation is stressed. Main elements of short-term and long-term strategies are outlined. They incorporate among others the introduction of flexible standards and economic instruments for the entire water consumption cycle, a precise scheduling of actions needed furthermore the application of alternative and innovative technologies. The latter are discussed with special emphasis on short-term effectiveness and gradual extension possibilities considering urban and rural areas, and approaches to efficiently close material cycles.

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1 Introduction

A growing number of publications recently discuss environmental and water pollution problems of the region of Central and Eastern Europe (CEE) and the Commonwealth of Independent States (CIS) (see e.g. Singleton (1987), Somlyódy & Hock (1991), Somlyódy (1991), Alcamo (1992), Golitsyn (1992), Hughes (1992), Moldan & Schnoor (1992)). These illustrate continuous changes in terms of judgement, order of magnitude, and controlling possibilities of pollutions of various kinds. The presence of transboundary pollution has been realized only nowadays among "new" states on the territory of the earlier U.S.S.R. Drastic economic alterations and crises significantly influence pollutions from various sectors. For instance, due to the decrease in fertilizer application in Hungary, parameters of the nutrient household have shown 20–40% improvement for a number of rivers in 1991 as compared to previous years. The decline of industrial production and the shut-down of many plants led to one or two classes of improvement in the quality of some of the heavily contaminated rivers. These changes, unrelated to any systematic management actions, clearly show the existing opportunity to couple environmental management and economic transformation.

In contrast to transboundary, industrial, and agricultural pollutions, urban ones and their control are hardly affected by the present transition. The reasons are at least threefold:

(a) the modest and strategically often mismanaged development of urban water resources systems during the past forty years resulted in a stage which is far from European standards;

(b) the pitfall of this development was recognized at least a decade before;

(c) the investment costs requireed to improve the present situation would cause an enormous burden even for stable economies (we mention that the solution of wastewater treatment and sludge handling in Budapest alone would require about $1 \cdot 10^9$ USD).

So, while for industry and agriculture the major question is whether the present opportunity can be utilized by a carefully designed economic and environmental policy, urban water resources management form quite a different task. Here the dilemma is how to develop a strategy which is in harmony with needs of economic transition and existing social problems (for instance the per capita GNP is at the level of 1/8–or less–of the Western countries). Since governments have limited possibilities to spend capital funds for environmental management not too far from the required ones, the issue is to work out a policy which is cost effective in the short run and gradually adjustable as long-term objectives are considered.

The main purpose of the present paper is to analyze the above issue. In the course of doing so, integration in the management approach will be looked for on various levels such as wastewater collection - wastewater treatment - receiving waters (affected also by pollutions other than urban ones), the urban water consumption cycle and finally urban metabolism as a whole.

Subsequently, we outline past developments of urban water resources systems. This will be followed by identifying impacts on quality of receiving waters and the role of priorities. The last portion of the paper will be devoted to discussing some of the main elements of future management strategies.

2 Past Development of Urban Water Resources Systems

In spite of the increasing number of publications already referred to and various national and international programs, no comprehensive evaluation is available for the region of CEE and CIS. For this reason we have to rely upon scarce and often contradicting information. Our analysis will obviously be sketchy (which primarily relies upon Polish and Hungarian studies, see Kindler (1989), Somlyódy & Hock (1991), OVIBER (1991)) but still realistic in identifying overall features of the management problem.

Significant urbanization took place in the region during past decades. For instance, urban population forms 60% of the total in Poland and Hungary at present. The increase was about 20% in the course of the past 30 years (this was associated with a demographic increase above 10 million inhabitants in Poland, Kindler (1989)).

About 90% of the urban population is supplied by public water in Poland and Hungary alike. Though this value is below Western European figures (97–99%) it is still acceptable, at least as the quantity is considered. The situation is much worse for the rural population where the public supply (20% and 48% for Poland and Hungary, resp.) is far below the standard of the developed European countries (about 90%). Water losses of municipal supply systems can exceed 30% indicating the significant need of reconstruction and modernization.

The unadvised development of the water infrastructure is well characterized by the lack of concern to build up wastewater collection capacities simultaneously (or precedingly) with that of public water supply. As an example we note that in 1950 28% of the population in Hungary was connected to public water supply, while 18% to the sewer system. Today the corresponding figures are 92% and 51% (65% for towns) resp., i.e. the utility loop has grown from 10% to more than 40% (an average value for Western Europe is around 20%), leading to contamination of surface and subsurface resources utilized eventually for drinking water purposes (this is one of the reasons of the well-known nitrate problem). Similar to the water supply system, the wastewater collection network of cities is also in a poor condition technically. Rural regions are again in a particularly critical situation where less than 10% is served by the public sewer network (the overall pattern is similar in Poland).

The level of sewage treatment is unfortunately even below the development of the sewerage. In Hungary, less than 35% of the collected wastewater is treated biologically, and 55% is characterized by no treatment at all (OVIBER (1991)). Biological treatment does not even reach 20% for Budapest.

In Poland only half of the cities are provided with wastewater treatment plants and the construction of more than 200 plants is half-completed (Hultman (1992)). The overall treatment level is similar to that of Hungary: about 40% of domestic wastewater is treated biologically, while more than 40% receives no treatment (the situation is somewhat better in the C.S.F.R.). In Warsaw the largest portion of the sewage is discharged raw into the Visla River. In Estonia only 20% of the total annual wastewater amount is treated biologically, while 25% mechanically (Hultman (1992)). The first larger treatment plant in St. Petersburg started to operate in 1987, only.

Treatment of municipal wastewaters is further complicated by the high contribution of industrial effluents discharged frequently without pre-treatment to the collection network. This ratio is 20% on average for Hungary (it is higher for Poland and the C.S.F.R.).

As we can see, the urban water cycle is rather open. The situation is even worse however if we consider the cycling of materials, primarily C, N and P. The low degree of wastewater treatment is only one of the reasons. The existing high loop is further amplified by the lack of proper sludge handling, disposal, and utilization. In Hungary, about 700.000 m^3 sludge is produced annually, the disposal of half of which is solved at best (OVIBER (1991)). In Poland, the accumulated amount of solid wastes is estimated at 1650 million tons. The city of Prague has secondary treatment, but it has no site to dispose of its stabilized sludge and thus must release it back into the Vltava River (Moldan & Schnoor (1992)). Budapest also suffers from sludge disposal difficulties. Due to lacking industrial pre-treatment, sludges leaving municipal sewage treatment plants are often classified as hazardous ones, thus prohibiting the usage of traditional disposal methods.

3 Impacts on the Quality of Receiving Waters and the Role of Priorities

Urban pollutions influence in many different ways the quality of receiving waters. If we consider a system of a combined sewer network and a waste water treatment plant we could observe in the receiving water aesthetic, bacteriological, and algal growth problems, and the consequences of the accumulation of toxic materials, depending on design and operation. Occasional impacts, primarily related to stormy events and overflows, may include local fish kills due to high ammonia concentrations and oxygen depletion. This kind of local problems can be overcome by properly integrating sewers, treatment plants, and receiving waters, with a strong focus on requirements of the latter one (see e.g. Lijklema & Tyson (1992)). It is argued however that the majority of urban water infrastructures in CEE and the CIS is not yet in a stage that the above integration would be a realistic task and the control of urban pollutions have a much broader dimension requiring a strong focus on regional planning. The reasons are manifold:

(a) Most of the receiving waters in CEE countries and the CIS simultaneously serve as recipients of untreated or unadequately treated effluents and resources for water supply. As a consequence of continuous pollution, furthermore accumulation of various materials in groundwater and sediment during past decades, quality of waters is rather deteriorated causing serious problems for water uses (often even for industrial purposes). For instance, 1987 data of Polish rivers show the seriousness of the present state. According to them, integrated quality classes were found as follows (Kindler (1989)): Class 1 - 5%, Class 2 - 27%, Class 3 - 26%, and Class 4 - 42% (the state of surface water quality is better in Hungary, see Somlyódy & Hock (1991)). The shallow aquifers are highly contaminated over large areas of Hungary, the C.S.F.R. and Poland alike. Nitrate concentration around 200 mg/l is observed in regions of intensive fertilizer application and/or inadequate sanitation facilities.

All these mean that decisions in relation to particular urban water infrastructure development cannot be made on an individual and local basis but rather a country or region wide strategy is needed in order to set priorities. The latter should be prepared by analyzing the quantity, quality, and vulnerability of resources, by preparing a pollution inventory, and by formulating future goals of water resources- and quality management.

(b) Such a strategy is obviously strongly depending on issues of managing shared water resources. If, for instance, there is an international action program to control the quality of the Danube, this will change country priorities. The latter should further be modified if the program incorporates a restoration of the Black Sea (which would be a logical decision). Such an abatement program would immediately call for P and N removals at wastewater treatment plants increasing investment and operational costs. Actually, this is already the case for Poland. More than 45% of the population of the region of the Baltic Sea live in the country. Their contribution to the Sea's total BOD load is about 20%, while it is 35% for P and N (Kindler (1989), Hultman (1992)). It is evident that under such conditions the strategy of the country for controlling urban pollutions (on both short- and long-terms) is a function of the outcome of international negotiations related to the Baltic Sea.

(c) The preparation of the above policy is strongly influenced by cost relations and public perception. Here pollutions of other origins than urban ones can play a significant role. We suffice to mention the high contribution of industrial discharges to wastewaters of combined sewerages of many cities at present and pre-treatment needs associated. The public choice can have an impact on specifying priority regions. A related question is for instance, to what extent should a well-developed city or recreational area of national asset character (Prague, Budapest, Lake Balaton, etc.) be preferred also in the future or should rather backward regions (e.g. rural settlements covering about 40% of the population in the C.S.F.R., Poland and Hungary) be considered?

The review of past developments of urban water infrastructures in CEE countries (and the CIS) clearly identifies a non-sustainable scenario of neglecting to close material cycles and disregarding the interests of future generations. The strategy of the coming decades should be based on quite different principles. It should properly integrate social, economic, and technical elements. The preparation of such a policy is an extremely difficult task and creates a major challenge for the society and professionals alike.

4 Main Elements of Future Management Strategies

As a starting point we summarize major features of the present state of urban water resources problems in Central and Eastern Europe. These can be characterized by attributes as follows:

(a) Low development of sewerage and wastewater treatment, as well as high utility loop and open material cycles;

(b) A significant portion of the (aged and unfinished) infrastructure is given which makes it difficult to introduce new methods on the basis of innovative principles (see later);

(c) Industrial discharges not treated adequately contribute significantly to the amount of wastewaters conveyed by sewer networks;

(d) Sludge handling and disposal are not solved properly;

(e) Large difference in the degree of development in urban and rural areas, resp.;

(f) Unrealistically high investment requirements (in the order of magnitude of $10 \cdot 10^9$ USD solely for Hungary) unlikely to be met for the coming decades;

(g) Difficulties in safe water supply and increasing treatment costs as quality deterioration of available resources proceeds;

(h) Transition in terms of preparing new laws and legislations related to environment, water and development;

(i) The desire to join the future community of Europe which would call for the acceptance of respective EC directives.

The above list specifies self-evidently some of the actions needed such as setting priorities, pre-treatment of industrial discharges, utilizing and upgrading existing capacities of the collection network and wastewater treatment facilities depending on their relative development (e.g. one of the two treatment plants of Budapest cannot operate close to the design condition because of lacking sewerage), solving existing sludge disposal problems and so forth. We turn our attention subsequently to elements of future strategies which are less obvious.

4.1 The Role of Laws

In all the countries of the region of CEE and the CIS strenuous work is underway to prepare laws corresponding to the changed political and economic situation. New environmental laws are generally missing at present. We argue that the pre-condition of sustainable future strategies is laws reflecting a holistic approach. To illustrate the importance of this statement and negative consequences of not applying a systems view, we refer again to the example of Hungary where, due to political reasons and misinterpreted public perception, water supply was developed at a much faster rate during past decades than sewerage and wastewater treatment (see earlier) and contamination consequences were completely disregarded. Strategies worked out recently (see e.g. OVIBER (1991)) define future development needs stemming from the present unbalanced situation. However, in the meantime the law of local governments specified in detail the development of public water supply and set the target for safe water supply for the full population of the country by 1994. Investment needs are estimated around $3 \cdot 10^9$ USD. The above legislation took place prior to formulating the environmental law, and without regulating how to handle the increased amount of sewages. The end result is the additional opening of the utility loop, growing contamination of receiving waters and as a result of this, increasing difficulties in uses and treatment of the same waters. It is noted that the above decision now really met public perception which is high towards safe water supply and still relatively low as pollution impacts are concerned.

4.2 Policy Instruments and Issues Related

The past system of policy making, management, administration, legislation, etc. related to water in CEE countries, incorporated seemingly nearly all the well known tools employed in market economy countries. This statement equally applies to policy instruments (fees, fines, charges, tax allowances, subventions, etc.). Unfortunately however, the system was unable to operate properly due to obvious political and economic reasons.

As an example we mention water price and sewage fines which were set independently and thus they did not enforce to close material cycles of urban metabolism. Water price was nominal and practically unchanged till the late eighties. The average sewage fine was less than one cent per m^3 in Hungary in 1988 (about two orders of magnitude smaller than the cost of sewage treatment).

During the past two years water price and sewage fine have been changed to different extents from country to country. Water price has been raised not rarely by an order of magnitude thus reaching comparable levels to those of Western European countries. The change led to a 20–30% reduction in the consumption depending on regions in spite of the overall low degree of supply of metering devices to apartments (thus not really offering effective and equitable incentives). In addition to positive consequences of increasing water price, there were also negative ones: due to the lack of an integrated preparatory evaluation, quite a number of wastewater treatment plants operate nowadays below design conditions.

The modification of sewage fines often did not follow that of the water price. For instance, in Hungary the level of fines is unchanged since the early eighties and the introduction of a new system cannot be expected prior to the approval of the environmental law under preparation.

It is felt that soft tools of environmental- and water quality management are extremely important under the present transition in CEE countries (and the CIS). The examples outlined above intended to illustrate that the setting of new policy instruments can only be successful if they cover in an integrated way the entire system of the urban water consumption cycle.

The same holistic approach should also be followed for defining standards. Some of the CEE countries had quite well established systems of standards for sewage effluents, receiving waters, and water supply, resp. (sometimes limit values were set unrealistically low or high). In spite of this, a well-defined inspection strategy for controlling the compliance with standards set and enforcement associated was missing for all of the earlier socialist countries.

Standards are revised nowadays in many countries of Central and Eastern Europe. There are serious discussions to introduce the U.S., the German, or the French system. However, it is our strong belief that this is not the right approach. Changes required in economy and environmental management are so drastic that experiences of the Western world should not be transferred without careful adjustments to the specific conditions.

In terms of standards (and policy instruments) the application of a flexible system is required which utilizes experiences available on effluent standards, technology based standards, and ambient water quality ones, resp. This would lead to a mixture of the previously listed three systems. Ambient standards open avenues for systems analytical evaluations and cost-effective strategies of crucial importance nowadays. Technology based standards can serve as guidelines for judging the feasibility of limit values. However, as they are not obligatory, they would allow the usage of various methods of upgrading and alternative methods (see later).

Standards should vary regionally expressing the needs of protecting waters and considerations of zoning. Simultaneously, regionally altered limits should represent priorities the importance of which was mentioned several times before.

Flexibility obviously means that standards should be continuously modified as transition proceeds and they should be adjusted to norms of the developed world. The same statement applies also to the EC directives on sewerage and waste water treatment. The recommendations of the community can only be realized gradually over a much longer period of time than planned for present member countries.

We are aware of the fact that the implementation of such a system is not easy. The price for the flexibility can be a complicated administration and enforcement procedure. Another real danger is that if the system is too open, it can offer plenty of possibilities for abuse and manipulation for the advantage of the polluters. Thus, the conclusion is that a systematic design is necessary which warrants flexibility on one side and rules out signs of weakness on the other side.

4.3 Alternative and Innovative Technologies

Investment costs required to solve problems of water supply, sewerage, and wastewater treatment should be close to one hundred thousand million dollars in Poland, the C.S.F.R., and Hungary. Several thousands of sewage treatment plants should be constructed, completed, or re-constructed. Simultaneously, collection networks of several ten thousand kilometers should be created. All this should be done under seriously uncertain economic conditions and strict budgetary constraints.

Using traditional thinking and technologies, the problem cannot be tackled. For this reason alternative methodologies corresponding to local conditions should be looked for whenever possible. If we consider sewage treatment, such technologies are looked for which

(a) lead to cheap (low investment cost) solutions of economic lifes of at least twenty years; and/or

(b) can gradually be extended (in terms of quantity and effluent quality) according to long-term requirements.

The first group is formed by a large number of techniques such as septic tanks, land treatment systems, lagoons of various sorts, the root zone method, artificial wetlands, and other alternatives of small wastewater treatment plants. These and their combinations can result in cost-effective solutions where site-specific conditions are favorable (e.g. land availability, proper soil composition) and the construction of sewer systems can thus be avoided. In other words, these on site methods are particularly well-fitted to rural settings causing significant problems in the region of CEE and the CIS (see earlier). Advantages, disadvantages, and details of on site wastewater disposal are discussed in detail in the literature (see e.g. Laak (1986)).

In a broader framework of material cycling ecologists start to question whether a large collection and concentration of wastes in one spot is a sound principle (even if justified economically). Niemczynowicz (1992) argues that urban development and water management requires a holistic approach representing a new technical paradigm. He summarizes key words and features of the future ecological scenario deviating significantly from the high tech one as follows:

(a) small scale treatment,

(b) source control instead of the "end-of-pipe" approach,

(c) local disposal, recycling, and reuse,

(d) pollution prevention, and

(e) the use of biological systems and findings of ecological engineering.

The implementation of these ideas expressing needs of closing water and material cycles is not easy for cities where a significant portion of the infrastructure is already given. Rural settlements are however in quite a different position. Here broad possibilities exist to introduce innovative methods starting even on the household level by separating different wastewater streams.

The possibility of step-by-step extension of treatment plants of cities in CEE is an important criterion to develop cost-effective strategies which can be realized in the nearest future. In this respect the traditional biological treatment is not attractive because if only the primary unit is constructed, the treatment efficiency is not satisfactory (about 60%, 35%, and 20% for SS, BOD, and total P, resp.) and investment costs are high otherwise (i.e. with the secondary unit). An upgrading of the primary treatment is possible by adding chemicals. The technology thus obtained is called chemically enhanced mechanical or advanced primary treatment (see e.g. Harleman & Morrissey (1990), Odegaard (1992)) forming an alternative to biological treatment. It requires minimal excess construction to a conventional primary unit and little capital cost. As chemicals aluminum sulphate or iron chloride and an anionic polymer are used. A survey of 87 Norwegian plants has shown (Odegaard (1992)) that average removal efficiencies of 91%, 81%, and 94% were achieved for SS, BOD, and total P, resp. (independently on whether a flocculation basin was built in or not). Other experiences show somewhat lower values: 80%, 60%, and 85% in the same order as before (Morrissey & Harleman (1990)). These are close to SS and BOD removal rates of biological secondary treatment (around 85%), while the effectiveness is higher by more than 50% for total phosphorus (only around 30% for biological treatment). Heavy metal removal is also effective; it varies between 50% and 83% for various elements according to the Norwegian survey. The amount of sludge produced is slightly less than for biological treatment and further reduction may be achieved by proper combination of different chemicals. As disposal is considered, for instance 40% of the sludge is used in Norway on farmland subsequent to thickening and dewatering. Operation costs are also competitive (see Morrissey & Harleman (1990), Odegaard (1992)).

Advantages for future applications of chemically enhanced mechanical treatment in CEE (and the CIS) are manifold. We list some of the most important ones as follows:

(a) Significant increase in removal rates of SS, BOD, and total P on the price of little capital cost in comparison to primary treatment;

(b) Small investment cost requirement as compared to biological treatment;

(c) Efficient removal of heavy metals being a major advantage if the contribution of industrial discharges is high;

(d) Decreased sensitivity of the primary clarifier on the fluctuation of surface overflow rate;

(e) The gradual extension possibility: if needed, an activated sludge or trickling filter system can be added later on (with a reduced size as large quantities of organic matter are removed precedingly during advanced primary treatment). It is noted that biological treatment may also be necessary to achieve increased nitrogen removal;

(f) Lastly, the easy adjustment to requirements of the receiving waters is mentioned (if policy instruments are flexible enough). For large recipients of high self-purification capacity (such as the Danube) advanced primary treatment can result in the long-term solution while for smaller ones technological units can be added depending on the particular condition.

5 Conclusions

Underdeveloped and aged urban water infrastructures furthermore open utility loops cause serious pollution problems in the region of CEE (and the CIS). Investment requirements are enormous which cannot be met under the present economic conditions. A careful planning procedure is needed on the basis of defining objectives (short-term and long-term ones) and setting national and international priorities (the latter for shared water resources). The precondition of a sustainable future scenario is the establishment of advanced environmental laws and legislation expressing a holistic view. Flexible standards and policy instruments should be defined for all the elements of the urban water consumption cycle according to local conditions but the one-to-one transfer of Western systems should not be considered. Important elements of future strategies are precisely scheduled actions for utilizing unbalanced capabilities of various units of existing infrastructures, upgrading, and alternative and innovative technologies. Chemically enhanced mechanical sewage treatment easy to extend gradually according to the requirements of receiving waters is considered as a particularly attractive method for urban areas. For rural regions an ecological scenario is recommended which focuses strongly on closing material cycles. Major features of the strategy are defined by small scale treatment, source control, local disposal, and reuse, furthermore the application of findings of ecological engineering.

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