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A conceptual analysis of the relation between human activities and river quality deterioration in the Volga-Don basin (Russia)

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Summary

The Volga and Don rivers are representative of the analysis of river restoration problems in the South-East Europe. A hierarchy in the dimensions of the rivers from the Volga to numerous minor tributaries, their many uses, and different kinds and degrees of degradation require a hierarchy in the aims of the policies, planning and implementation of river restoration.

The principal causes of degradation of the Volga are closely connected with dams, sewage and irrigation, which lead to reductions in potable water supply, the fishery and biodiversity. The main problem for small rivers in the Don basin is water shortage. Therefore the aims and methods of river restoration for small and large rivers are different. However, they have to be achieved through a common scheme of coordinated arrangements. This scheme is based on systematic and targeted approaches and includes, on one hand, the removal of some dams, reduction of pollution, restoration of water volume and biodiversity, and on the other hand, the settlement of conflicts through negotiated agreements and the involvement of public opinion.

The target programming of river restoration is a process of some specific iterative procedures, including theming, analysis of the situation, goal setting, problem evaluation, conversion of problems into tasks, and planning. The Federal Target Programme, *Volga Revival*, follows this sequence of operations, and extends to some measures for the restoration of minor rivers in the Don basin.

Introduction

The restoration of rivers, like any complex problem, demands for its resolution an application of the particular methodological approaches that adequately reflect a main problem - optimum management of a state of the river. There is a wide international experience in solving the problems of river restoration in the United States and European countries. The issues of land-use impacts on water quality and integrated modelling system of management of river basins have been analysed by Bronstert (2001) and Rousseau *et al.* (2000). The works of Barrow (1998), Bhowmik (1998) and Fenz *et al.* (1998) give a general overview of integrated approaches related to river basin management, including small rivers.

In our investigations we use such systematic approaches to establish a hierarchy of water bodies, their structure and functions, and create programmed targets. This ensures the transition from evaluations and forecasts of a state of the river to a programme of concrete measures for its restoration (Shubin, 1987).

It is important to note that the process of programming represents a particular set of iterative procedures, whose basic content includes: theming, analysis of a situation, goal setting, problem evaluation (revealing the conflicts), translation of problems into tasks and planning (projection) of measures. Thus it is necessary to take into account that the programming at each stage, except for projection, is carried out in alternative variants. We use the theoretical aspects of a problem of river restoration, surveyed above, for practical solutions in the region of the Lower Volga and part of the minor rivers of the Don basin (Fig. 1).

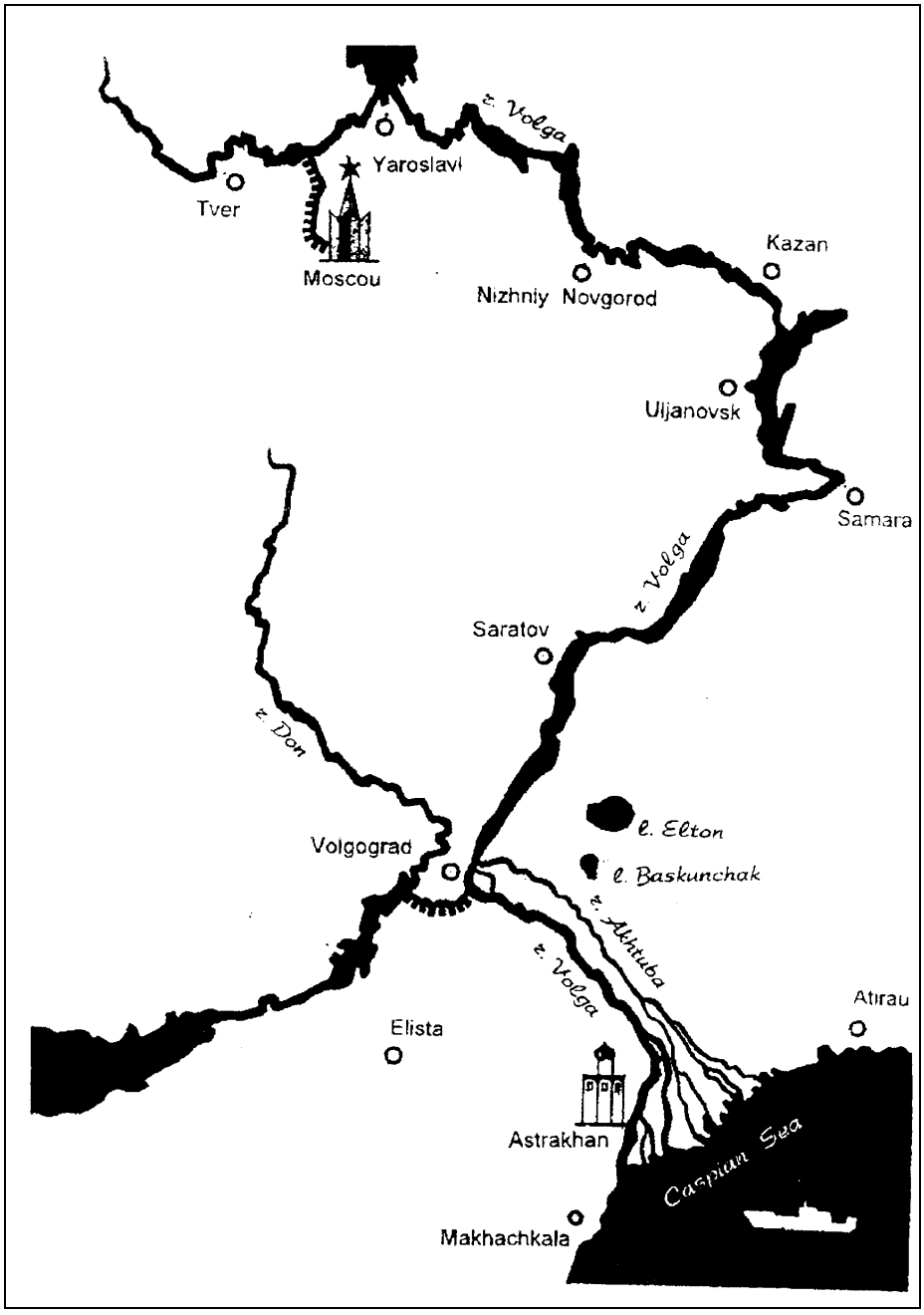

Fig. 1. Volga-Don Basin

VOLGA BASIN

The huge dimensions of Volga basin and the duration and intensity of its economic development define the scale of the ecological problems of this region and the complexity of the solutions for its restoration. The structure of the hydrosystem of the basin includes the two largest tributaries, Kama and Oka, plus 2600 medium-sized and minor rivers, 11 large dams and reservoirs of Volga-Kama cascade and hundreds of storage lakes on small inflows.
Procedures for planning the Volga restoration are presented below.

Theming

The development of the programme of river restoration begins with theming, that is the definition of a set of questions and directions that the programme should survey. Theming is carried out as widely as possible: from general approaches and principles to the detail, from directions of activity to financing and the staff of the executive agencies.

In this case programming is based on the complex use of the so-called "natural" approach, viewing actual processes in the river basin, with the systematic and target-programmed approaches characterised above.

The main principles on which the programme of Volga restoration is based are:
- The programme is carried out according to state strategy of sustainable development;
- The programme is a constituent of the Federal target programme, "Revival of Volga";
- The development and realisation of the programme is carried out by collaborative efforts of member states, regional and local administrations, industries, scientific institutions and public organisations;
- The measures of the programme should take into account alternate variants of the trends of development of socio-economic and ecological requirements.

Radiating from this, the basic themes of the program of Volga restoration are the following:
- Influence of hydrotechnical constructions;
- Geoecological situations (inundation, landslides, erosion, destruction of coast);
- Action of industrial and power plants and water transport;
- Influence of a municipal services of cities;
- Role of agriculture;
- Problem of biodiversity;
- Health and mortality of the population;
- Monitoring and information maintenance;
- Statutory and regulatory acts;
- Ecological education and development;
- Financial and economic maintenance of the programme.

Not all these themes can and should be developed simultaneously and to the same degree. For each water body or investigation phase any of themes can prevail, however for basin as a whole the list creates a framework, inside which the further procedures of programming are carried out.

Analysis of situation

The analysis of the situation is carried out according to the themes of the programme. The integrated analysis of the ecological situation in the Volga basin has been described in several published monographs (Komarov *et al*., 1993; Komarov *et al*., 1996; Naidenko *et al*., 1993; Shubin, 1986). Similar investigations with interesting and useful results concerning river basin management were carried out in the USA (Kondolf, 2001), in Austria by Cate and Tyson (1999), in Belgium (Goethals and De Pauw, 2001), in Portugal (Machado and Alves, 2001) and in the Rhine river basin by Wieriks and Schulte (1997). Therefore we shall briefly estimate the ecological situation necessary for the further programming.

There is no doubt that **hydrotechnical constructions** have caused, along with pollution, the degradation of the aquatic ecosystem of Volga basin. These dams were built for irrigation and hydropower generation. The largest part of the water area represents overgrowing shallows (Table 1). It is necessary to note that electric power developed by the cascade does not exceed 5 % of the total amount in the country, and the energy contribution of the Upper-Volga dams in particular is insignificant. More than half of total extent of the coast is subject to landslides, erosion and abrasion.

Table 1. The general parameters of Volga-Kama cascade

Reservoir	Year	Volume, km^3		Water-surface area, km^2	N W L, m	Discharge, Q max, m^3/s
		total	effective			
Ivankov (upper)	1937	1.12	0.81	327	124.0	7 400
Uglitch	1939	1.25	0.81	249	113.0	13 000
Ribinsk	1940	25.42	16.67	4 550	102.0	9 000
Gorky	1955	8.82	3.90	1 591	84.0	15 100
Cheboksary	1981	4.60	0	1 080	68.0	40 800
Kuibishev	1955	57.30	33.90	6 150	53.0	70 800
Saratov	1967	12.87	1.75	1 831	28.0	53 000
Volgograd (lower)	1958	31.45	8.25	3 117	15.0	63 060
Kama	1954	12.20	9.80	1 915	108.5	21 000
Votkinsk	1961	9.40	3.70	1 065	89.0	19 300
Lower Kama	1978	2.80	0	1000	68.0	34 900

Water consumption by industries, farmers and municipalities leads to the pollution of the rivers. The problems, bound with **shipping**, are less significant and are connected to pollution of water bodies. The situation, however, can become complicated in connection with plans to in-

crease the transport of petroleum and other loads on the Volga, bridging basins of the Baltic, Caspian and Azov seas.

Agriculture influences mainly the water supply, and in the southern part of basin, an irrigation system. Also, the role of water pollution from the use of fertilizers, cattle-breeding farms and plants that process agricultural products is significant.

The assessment of the aquatic ecosystem plays a major role in drawing attention to the threat to **biodiversity** in the river system. The situation with the fisheries deserves special attention. Here the negative influence of hydraulic structures and water pollution has appeared to be catastrophic for the most valuable fish species, in particular, sturgeon. Obstructing the fish migration paths with dams and removal of natural spawning sites led to the decrease of natural breeding of sturgeon below a critical level. From 4000 hectares of spawning areas in the valley of Volga only about 400 hectares remain in a bay near Volgograd. Existing fish ladders at two dams to restore fish migration proved to be absolutely ineffective.

Changes bound with flow regulation are seen in the flora and fauna. The area of floodplain forests, especially oak, is reduced in connection with damage by ice at artificial winter high waters.

However, the actual ecological situation in the Volga basin is far from that described in alarmist evaluations, such as in "Ecocide in Russia". Certainly, here, as in any advanced countries, there are local polluted industrial zones, but it is important to note that the Volga basin, with its rich biodiversity and perfect places for recreation and tourism is unique in Europe. It is necessary to avert the further deterioration of an ecological situation and to plan effective ways of elimination of negative influence on the nature of this territory.

Goal setting

The situation analysis is a basis for development of hierarchical system of the purposes of the river restoration program. The hierarchy of purposes is determined on different spatial levels: federal, basin, regional and local. Thus we have to take into account the differentiation of the purposes on directions of activity, including industries, hydropower generation, housing, agriculture, biodiversity conservation.

It is important to note that on the federal or basin level it is possible to formulate the general objective of river restoration: radical improvement of the ecological situation. However, on lower levels the objectives of development frequently are not only different, but can become competitive. So, objectives of an industry, hydropower generation and agriculture are aimed at maximum output of production at the least expense. On the other hand, the objectives of enriching biodiversity can be achieved only by cutting down the negative impact of industry, hydropower engineering and agriculture on the environment, which actually in Russia means the closure of many factories and elimination of dams and other large structures. Besides that, conflicting objectives sometimes arise at a level of the locus of Federal and municipal administrations and separate plants with different socio-economic potential. The contradictions of

objectives generate conflicts, especially noticeable at interbranch and interterritorial levels.

Problems evaluation

Discovery of conflict situations and problems arising is carried out within the framework of this procedure of programming. The basic conflicts in Volga basin are seen between the representatives of industries, hydropower plants, fisheries, agriculture and navigation. The core of the conflicts lies in the various demands to a regime of flush through dams of Volga-Kama cascade. The industry requires a peak diurnal load, but the difference in loads leads to sharp oscillations of the water level, which is negatively reflected in the work of water transport. High level of water for the needs of fisheries, necessary for fish reproduction, conflicts with the interests of an industry. The winter accumulation of water that is important for hydropower generation leads to seasonal high waters that negatively influence biodiversity conservation in Volga-Ahtuba floodplain and a delta of Volga.
Besides this rather substantial conflicts arise between territorial and municipal authorities in connection with excess of water use quota or catch of fish, and also with the solution of questions on compensation of damage from contamination and their transboundary movement downstream Volga. The analysis of the roots of such conflicts enables us to reveal problems and develop new means for their solution.

Conversion of problems into tasks

The conversion of problems into tasks also is such a programming procedure, when on the basis of priorities the substantially achievable problems of river restoration are defined. In our case, we as the representatives of nature protection organisation choose ecological priorities.
Radiating from this, the basic problems of regeneration of the Volga are the following:

- Cutting industrial pollution through reconstruction of the plants with introduction of low-waste technologies;
- Regeneration of the natural hydrological regime of the Volga by eliminating hydroelectric power station dams with simultaneous building of gas-steam thermal power stations to compensate for losses in the country's power generation;
- Engineering protection of land against action of geo-ecological processes;
- Cutting water use for industrial, municipal and agricultural purposes, including irrigation, by decreasing the loss of water;
- Reduction of the level of environmental pollution by elimination of solid waste sites, sewage and its utilisation;
- Regeneration of the minor rivers in the basin;
- Regeneration and conservation of biodiversity at the expense of creating a wide network of special nature protection areas, introduction of ecological principles of land tenure;
- Building of favourable conditions for breeding of fisheries;
- Reduction of disease incidence and mortality of the population;
- Building and providing a network of ecological monitoring with modern equipment;
- Development of a scheme of ecological education;
- Creating adequate statutory and regulatory standards.

Certainly, intense debate among the participants in the process of river restoration arises at the discussion of a question about elimination of dams. The basic reasons against such solution are connected, first of all, with necessity of compensation for losses of the electric power, deterioration of conditions of water supply, navigation and irrigation, problems of high water and dispelling of salts of heavy metals from dried up deposits of reservoirs (Avakian, 1999). Technically these problems can be solved, though they will require rather considerable expense. For example, the project of a potent thermal power station near Volgograd was designed and has passed ecological expertise. There are also other designs for the development of power in the Volga basin, sufficient for neutralisation of losses after elimination of hydroelectric power stations. For maintenance of navigation in low water it is necessary to deepen a ship course, however these expenses are much lower than losses of time and resources on locks at dams on Volga and Kama. The problems of water supply under conditions of introduction of water saving technologies and dilating of use of ground water will not become more acute with the elimination of dams. As to salts of heavy metals, their concentration in bottom-dwelling deposits is much lower than in soils around the industrial centres of the Volga basin. Besides, the polluted bottom-dwelling deposits annually will be covered by new deposition, and after the wane of a high water these prolific grounds will be coated with meadow green with which the natural process of recultivation occurs.

The greatest problems can be connected to inundation during high flows, and their solution will require considerable expense. However, it is necessary to remember that the investment is in the state of the largest ecosystem in Europe with about 60 million inhabitants, which is still distinguished by a very rich biodiversity. One should not forget that the estimated time of operation of the majority of the dams is close to ending, and maintaining them in a safe state demands huge expense. Wouldn't it be better to direct them on the solution of ecological problems of Volga basin?

DON BASIN

The basic ecological problem of the Don basin is the degradation of minor rivers owing to flow abstraction. The huge amount of small weirs and dams on all large rivers and tributaries (more than 8600) intercepts a considerable proportion of the spring flow. In summer the water from shallow ponds and reservoirs is lost to evaporation and infiltration. A high proportion of cultivated ground, forest felling and destruction of primitive dams by high flow add to the volume of sediments and overgrowing of minor rivers. The water shortage in the Don and its tributaries exacerbates industrial and agricultural contamination (Kosolapov *et al*., 1999).

The solution of these problems is possible with the implementation of the set of measures including elimination of weirs and dams, clearing of the minor rivers and amelioration on flood plains and catchments. The volume of these works is rather considerable: about 65 million m^3 of dams need removal and more than 7000km of minor rivers require cleaning. We have to note that the removal of dams sometimes invokes the protest of the local population. In connection with this, it is simultaneously necessary to solve questions of water supply to villages by exploiting ground water, available here in sufficient volume.

Conclusions

The extreme complexity of river restoration management, especially large basins, demands, on the one hand, a carefully balanced approach, and on the other hand, implementation of particular solutions inherent to the specific characteristics of the water system and its use by local society. One has to recognise that none of "compensatory" measures, when there is preservation of dams, increase of freight traffic, shunt of sewage, can allow the restoration of an ecosystem of the river. For this purpose, cardinal measures affecting the interests of the industrial, hydropower generating and transport companies and all other stakeholders are demanded. In most cases, their activities have to be continued, but replaced by more sustainable and nature friendly processes. Certainly, the restoration process of an ecosystem does not bear "revolutionary transformations", but long and expensive efforts.

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