IRKUTSK REGION WATER RESOURCES EVALUATION

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The problem of harmonious exploitation basing on economical-ecological compromises is not new but still actual. Competent housekeeping (at any economic level) that was recommended in the ancient time by Aristotle wouldn't lead to the ecological crisis of nowadays. The mankind must understand that we all live on the same planet, and we are guilty in our problems but not those people of another nation or country origin. Conformism, indifference, laziness and simply unwillingness to think or to blame ourselves are the reasons of our current lawless position. Living on the territory that includes unique natural resources we couldn't defend the largest lake in the world – Baikal, we allowed to locate one of the largest pollution source on its shore, the Baikal pulp and paper mill.

The Irkutsk region water resources are one of the most valuable natural wealth. The aquatory square of the world-famous lake Baikal is 31,5 ths km^2, the extent from North to South is 636 km, max width is 79,5 km. With the average depth of 730 m and max depth of 1637 m, the potable water supply is 23,6 ths km^3, which is 20% of the world potable water supply. Besides, there are 229 more lakes in Irkutsk region, their total aquatory square is 7732,5 km^2.

The fluvial net is represented by the drainages of large rivers (such as Angara, Lena, Nizhnaya Tunguska) and their numerous inflows. The density of fluvial net is 400 m on 1 km^2. The main water artery is Angara River; its water regime is mainly defined by the lake Baikal that gives it 60 km^3 of pure water annually. On the 55^{th} km from the origin the river is blocked by the Irkutsk hydroelectric dam and forms Irkutsk dam lake. The square of the dam lake is 154 km^2, the shore length is 300 km, the water volume is 2,1 km^3. The regime of the Angara flow from Irkutsk to Bratsk dam lake depends on the Irkutsk hydroelectric station mode.

Bratsk dam lake is 605 km down the river. Its square is 5470 km^2, volume – 169,3 km^3, shore length – 6000 km. And the last hydroelectric dam on Angara forms Ust-Ilimsk dam lake 1026 km down the river. Its square is 1922 km^2, volume – 58,93 km^3, shore length – 2500 km.

For the period of Angara's hydroelectric stations exploitation two problems appeared (according to the governmental report "About the conditions and protection of the Irkutsk region's environment in 2003"): stream-bank erosion (Ust-Ilimsk water storage – 70 m, Irkutsk and Bratsk water storages – 200 m) and Baikal and Angara shallow that appeared in 1996 and led to the water storage discharge.

Besides, there is a systematical and inadmissible for harmonious exploitation water pollution, in particular, the pollution of Baikal Lake that led to the substantial negative changes in the lake's ecosystem. Anthropogenic influence on the Baikal is increasing since 1950. The logging on the rivers increased and there were started the rafting on the Baikal. Constantly growing amount of tourists doesn't promote the improving of ecological situation too. There is also sewage disposal from the Baikal pulp

and paper mill (BPPM), Slyudyanka city, Angasolka station, the quarry Pereval and the South-Baikal fish factory. There is the Baikal-Amur railway along the Northern bank, and there are about 90 units of private and departmental vessels. A portion of pollution is also brought in the lake by the ice crossings.

The observation of Baikal Lake pollution for the period 1993-2005 according to the data of the Irkutsk regional office on hydrometeorology and environment monitoring shows that disposal of not enough cleared sewage into the Baikal is performed by the BPPM (since 1966). It is located right on the bank and disposes the sewage right into the lake. In addition, there is a dump of not enough cleared sewage from Slyudyanka city (1463 ths m^3), Angasolka station (41,4 ths m^3), quarry Pereval (242 ths m^3) according to the data of 1993. Besides, there are economic-domestic sewages from vessels (0,7 ths m^3) that are not enough cleared because of the synthetic surfactants. Since 2005 the analysis of pollution by fluorides is held, the amount of fluorides in sewages is about 2,312 tones. In addition, the water is polluted by industrial releases, numerous boiler houses' and railway stations' releases. In general, the water quality is qualified by category II (conditionally clear), excluding the Maritui river mouth where the quality of water is III (moderately polluted) because of high concentrations of mineral oil and copper.

According to the data of 2003, the total sewage disposal in Irkutsk region is 1225,35 bln m^3, 1203,7 bln m^3 were dumped in the surface water that is 33,61 bln m^3 more than the previous year. Among the total sewage 639,4 bln m^3 are not enough cleared, 183,04 bln m^3 – not cleared, 360,3 bln m^3 – standard clear, 20,95 bln m^3 – standard cleared. In the surface waters of Angara basin 1124,4 bln m^3 of sewage were dumped, in the Baikal basin – 45,6 bln m^3, in the Lena basin – 33,7 bln m^3. The main pollution sources are pulp and paper industry enterprises (BPPM, BratskComplexHolding, Ust-Ilimsk timber industry concern), chemical, petrochemical and fuel industry enterprises (HimPromUsolye, SayanskHimPlast, Angarsk petrochemical enterprise), and housing and communal services.

The detailed description of all Irkutsk region water resources pollution exceeds the paper restrictions. It is absolutely obvious that the Irkutsk region ecosystem is already affected by the environmental impact. The river Angara is influenced even more in the area between Irkutsk and Angarsk cities. The main pollution sources close to Irkutsk are the sewages of left and right bank sewage treatment plants, Irkut enterprise, city storm flows. According to the pollution index the water of Angara near Irkutsk is qualified as category II. Near the Angarsk city the main pollution sources are the sewages of thermal power stations number 9 and 10, Angara-reactive factory and Angarsk petrochemical enterprise. The water here is qualified as categories III-IV.

Hydro-chemical observations of Bratsk dam lake are held at 13 points. Before the Bratsk dam lake the water of Angara is polluted by the Irkutsk and Angarsk enterprises. In addition, the sources of further pollution are HimPromUsolye, Usolye HimFarmCombinat, and pig-rearing complex. The concentration of chlorides is significantly increased (14 times), as well as the concentration of

sulfates (2 times). The water is qualified as category III. By the complex of parameters the water of the upper part of Bratsk dam lake is qualified as categories III-IV in general.

In the area of Balagansk settlement the water is qualified as category IV (polluted). In view of high mineral oil concentration the point is included in the Priority list of water objects, where immediate water-control practices are needed. The water near the dam in the area of Bratsk city is also highly polluted and is qualified as category III. In the Suhoi Log gulf of the Bratsk dam lake the water quality is impaired and is qualified as category V (dirty water). At the point of Dondir gulf the average annual concentrations are high and the water is qualified as category VII (extremely dirty).

Hydro-chemical observations of Ust-Ilimsk dam lake are held at 13 points. Its feature is in its non-uniform hydro-geological mode in different areas. The volume of the water is regulated by the Bratsk hydroelectric station's water dump. Accordingly, the water quality in the upper part of Ust-Ilimsk dam lake is defined by the pollution level of the Bratsk dam lake waters. The most polluted is the gulf of the Vihoreva river where the sewages of the following pollution sources are dumped: BratskComplexHolding, Bratsk housing and communal service engineering communications, city sewages. At the point of Sedanovo settlement the water quality is qualified as category VII.

Dam lakes are the reasons of many hydro-biological, hydro-chemical and biological modes changes. The flow rate of the rivers slows down, the depth of waters is changing, as a consequence, the fish fauna is radically changed. Instead of the valuable and numerous fish species the low-grade ones are widely spread: roach, darter, crucian and bream. The negative influence on the fishery product reservoirs is caused by the sewages and the huge amount of drowned timber.

At present the ecological situation in general is very difficult, especially in the areas close to the highways where anthropogenic influence is extremely high. Taiga territory, significant in the past, is crossed with clear cutting by 25-50%. The increase of cutting areas breaches the hydrological mode of the territory (floods happen more often, the water level in rivers and lakes decreases), changes the climate (sand storms appear and happen more often), negatively influences on the region's biodiversity. Moreover, the areas of intensive cutting are characterized with high flammability. Anthropogenic influence, including forming and expanding the urban territories, building dams and highways, developing the chemical industry, expanding the cutting areas and burned-out forests, leads to the significant changes in the space structure of separate populations and general assemblage of plants and animals. The diversity and total estimate of indigenous species continues to decrease at all ecological complexes. Dark coniferous taiga landscapes succumb their place to forest-steppe ones. In the agricultural areas there is a degradation of grass stand together with vegetation changes and, as a consequence, soil erosion.

Such changes are the direct consequences of environmental impact caused by mankind. Of course, we can connect this all with global climate changes which is con-

cerned with the global heating and century cycles. But what if the global climate changes are also connected with anthropogenic influence?

There is a necessity for the special activities targeted to stabilize the region's natural system. In particular, the development and working of ecological systems based on the technology of complex territory's ecological volume evaluation, with different exploitation modes that allow to preserve the natural homeostasis, targeted to preserve landscape and biological diversity.

Suggested technology is based on the space-time method of ecological-economical damage evaluation:

$$Ev = \frac{C_{dam} \cdot S_{dam}}{100 \cdot S_{gen}^{n}} \cdot R_{com} \cdot T_{\max} \cdot \left(\frac{1}{Sc}\right)^{n-1},$$

where S_{dam} – breached area; C_{dam} – breach rate; S_{gen} – total area of a level; R_{com} – the number of breached relations in natural system, in this case is equal to 3 (soils, waters and atmosphere); T_{max} – component's life time; S_c – scaling factor, takes value from 2,3 to 3,6; n – level number from 1 to the number of levels. The ratio $\frac{S_{dam}}{S_{gen}^{n}}$ is a space parameter, whereas $T_{\max} \cdot \left(\frac{1}{Sc}\right)^{n-1}$ is the parameter of natural system levels' interface changing time.

Replacing the *Cdam* by HPC and the areas by the volumes, we obtain the formula for water resources damage evaluation:

$$Ev = \frac{HPC \cdot V_{dam}}{V_{gen}^{n}} \cdot R_{com} \cdot T_{\max} \cdot \left(\frac{1}{Sc}\right)^{n-1}$$

But in this case we must take into account the spreading of pollutants in the water. In the stationary basins we can neglect the dynamics as the formula itself takes into account the spreading of damage on surrounding areas. As for the rivers, we can estimate the limits of pollution by adding the following formula: $L = v \cdot t$, where L – a distance that the pollutant will get over going down the river; t – the time of pollutant's dissolution; v – the average speed of the river.

The significant data amount, processing complexity, departmental interests etc. lead to the necessity to develop special technical (software) means. To facilitate the data processing and to visualize the ecological-economical damage caused to natural system by anthropogenic influence, the program product "WaterRisk" is developed.

A man lives in the natural system which is a system with limited energy resource defined by the known methods of obtaining the energy. Nowadays the mankind population's supply exceeded the possibility of natural system self-restoration. The further mankind development is impossible without ecological-economical com-

promises. Thus the complex analysis of territory's ecological volume is a necessary attribute of harmonious exploitation.

REFERENCES

Musikhina E.A. The Time Factor Influence on the Environmental Impact Evaluation in Conditions of Industrial Mining. – Irkutsk: ISTU publishing house, 2007. – 90 p.

The work was submitted to international scientific conference «Ecology and concervancy», Egypt, February 21-28, 2010, came to the editorial office on 02.02.2010.