Environmental Optimization Activities Depending on the Stress of Urbanized Floodplain-Channel Small Rivers’ Complexes

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Abstract. Environmental optimization as development and implementation of programs that include a complex of environmental engineering activities become a mechanism, capable of improving the ecological state of small rivers of large cities territory. First of all, it is necessary to conduct an integrated environmental assessment of floodplain-channel complexes of small rivers in urban areas to substantiate recommendations for environmental optimization, engineering activities to reduce environmental stress. The article proposes a classification of environmental optimization activities depending on the environmental stress of floodplain-channel small rivers’ complexes of urbanized territories. There are restoration, environmental rehabilitation, reconstruction, conservation and liquidation. Definitions, types of work and their examples are given taking into account Russian and foreign experiences. As an example, the conservation’s use of the floodplain-channel part of the small river Yeltsovka-1 in the city of Novosibirsk is proposed. The main sources of the strong environmental stress of the open section of the river are given, and also activities to conservation and environmental rehabilitation of the river. Later this section of the Yeltsovka-1 River can be used as a recreational area for the rest of the population, which will increase the attractiveness of a nearby residential area.

1. Introduction
The intensive development of large cities territory, carried out throughout history, is now considered as one of the most significant factors in the degradation of floodplain-channel of small rivers’ complexes. Environmental optimization of these territories is a mechanism, capable of improving the ecological state of many water bodies, since the general level of anthropogenic impact on the biosphere has reached a value at which natural processes cannot cope with this task. Environmental optimization is also development and implementation of programs that include a complex of environmental engineering activities to increase the result of positive impacts while reducing negative ones [1]. This task is considered as one of the main in the environmental management systems development. Their implementation in practice is difficult due to the lack of conceptual foundations of this activity methodology, allowing formulating specific tasks, which implementation would bring a tangible effect.

The development of the environmental optimization concept has a number of features. There are lack of knowledge, experience in environmental activities and technical systems are aimed at preserving and improving the environment of urbanized territories. Their little knowledge determines the impossibility of their use for the practical solution of environmental problems. Such one-sidedness
of the methodological approach is connected with the fact that the human impact on the environment was local in the previous historical period. At the present stage, the situation has fundamentally changed - anthropogenic impact leads to dramatic changes in the hydrological, hydrochemical and hydrobiological regimes of water ecosystems. Degradation of an individual water body in most cases is one of the particular manifestations of water basin degradation. River basin restoration projects have several advantages: an integrated approach to the restoration of natural water processes and biodiversity, attracting of local communities’ attention to environmental problems, and, therefore, stimulating all interested organizations to solve them, preserving the natural capital of the urbanized territory, creating the infrastructure of a green economy, improving the environmental culture of the population. It should be noted that water user enterprises are interested in the effectiveness of such events, since their results significantly affect their rating and investment attractiveness [8, 11, 12].

2. Materials and Methods
First of all, it is necessary to conduct an integrated environmental assessment of floodplain-channel complexes of small rivers in urban areas to substantiate recommendations for environmental optimization, engineering activities to reduce environmental stress.

The integrated environmental assessment of floodplain-channel complexes of small rivers in Novosibirsk was carried out in three stages [2]:

1. selection of the main phenomena and processes that have the most noticeable impact on the ecological condition of the channels and rivers’ floodplains and causing their adverse changes;
2. justification of the criteria for assessing environmental stress for each of the factors and their ranking;
3. obtaining a generalized indicator of the ecological state of the floodplain-channel complex, which takes into account the influence of each particular phenomenon and process on the overall ecological situation in river valleys.

The processes that determine the ecological state of cities’ small rivers include anthropogenic silting and channel degradation, their drying, changes in floodplain landscapes, as well as their intersection by communications, bridges, etc. [2]. These phenomena significantly differ in their structure, method of measurement and nature of distribution. Assessment of environmental stress associated with each type of process or anthropogenic change is ranked in five gradations, each of which is assigned a score depending on the degree of influence: the absence of negative impact corresponds to 0 points; the phenomena that caused the most adverse effects - 5 points. Scoring is carried out taking into account weighted correction factors, depending on the degree of influence of the factor [2, 3]. The generalized criterion for assessing environmental stress allows zoning of territories according to the degree of anthropogenic variability and can be used to justify the recommendations of engineering activities to reduce environmental stress [3]. There are restoration, environmental rehabilitation, reconstruction, conservation and liquidation.

2.1. Restoration
Restoration is a complex of engineering activities aimed at strengthening floodplain-channel complexes of small rivers. Restoration includes:

- cleaning the channel of trash, fallen trees, garbage;
- elimination of large garbage along banks of rivers and ravines;
- clearing springs, underground keys, sources;
- forest planting along the channels of small rivers and ravines;
- untreated effluent limitation into small rivers;
- creation of a network of ponds-silt traps and small reservoirs, primarily cascading.
2.2. Environmental rehabilitation

Environmental rehabilitation is aimed at maintaining a biologically balanced ecological water system, that works for self-purification and self-restoration, to combat the processes of eutrophication and waterlogging [4]. The work of the aquatic ecosystem may be disrupted as a result of the accumulation of natural organics (leaves, branches, feces of fish and waterfowl, dead aquatic plants) and / or intense pollution of a water body by technogenic organic substances and nutrients (garbage, storm or sewage wastewater, poorly treated sewage, etc.).

Environmental rehabilitation includes two stages of work:

- hydrotechnical and coast protection activities: works on cleaning the bottom of a water body from silt deposits, deepening the bed of a water body, etc.;
- bioengineering activities: purification of incoming water recourses, greening of the coastal zone, landing of water plants, formation of a hydroecosystem (populating it with plants, planktonic and benthic organisms and fish).

2.3. Reconstruction

River reconstruction is a set of activities aimed at the restoration of natural processes and biodiversity. Rivers have been changed by people for millennia: first as a result of land clearing for agriculture, and then in Roman times, rivers began to be diverted to protect against floods. The industrial revolution put new pressure on the freshwater environment, which led to a serious decline in water quality and, as a result, to the loss of biological diversity. The first attempts to rehabilitate rivers in the UK and Europe began in the early 1900s. Initially, it is included small-scale artificial change to improve the water ecosystem, but over time, the work on a catchment scale was given priority [5, 7].

2.4. Restoration of the natural river bed

In the past, straightening, diverting, and over-deepening rivers were common practice to create land for improve river navigation, improve land drainage, and reduce floods, etc. The straightened channels, as a rule, lack ecosystem diversity because their profile has been significantly changed and their features have been removed. Straightening can increase the risk of downstream flooding, as water moves faster through the modified section with increased flow. The return of the native channel restores a more native flowing and river profile in order to improve ecosystem diversity. The water stream can be returned to the previous flowing of the river or a completely new channel can be built if the old river bed cannot be identified.

2.5. Reconstruction of the river bed

If river floodplains were developed, as is the case in most urban areas, it is often not possible to make space for large-scale river rehabilitation. If the river has concrete banks or a channel, then restoration of some natural processes in the river channel can be carried out in the following way. Some shape of bottom roughness is introduced at the bottom of the river, such as wood material or processed gravel, berms are created (Figureure 1) to create a threshold. It also leads to increased biodiversity and improved ecosystems.

Thus, various engineering activities, including rehabilitation and restoration, can be used to reconstruct rivers.
3. Discussion

If the ecological stress on the river has reached four integral points, then it is not possible to restore it to native conditions without taking river conservation. River conservation is a set of activities to completely stop the harmful anthropogenic impact on the river. River conservation programs will be effective only if the environmental, economic, technological and social aspects of the problem are comprehensively reviewed. River conservation should be a joint effort of agronomists, industrialists, city managers, environmentalists and economists, in addition to state regulatory agencies. The main problem is the treatment of surface runoff (storm and melt water). The cost of introducing storm water treatment plants is high for municipalities that cannot afford it. The river conservation programs require constant investments. The presence of water protection zones, coastal protection strips is also necessary. Their presence prevents the pollution of a water body by surface runoff, transfers the surface runoff to underground, helps protect floodplain terraces from erosion, prevents the destruction of banks from erosion, rationally organizes the area near the water body [13-15].

After the conservation of the river, it is possible to carry out environmental rehabilitation, restoration and reconstruction of the river.

3. 1. Liquidation

When a crisis environmental situation is reached, the operation of a water body becomes life-threatening, and its restoration is impractical. In such situations, which arise very rarely, a set of activities is taken to completely or partially the water body liquidation. The choice of complete or partial liquidation depends on the technical and economic feasibility, an important criterion of which is the presence and level of groundwater.

Following activities are carried with the complete liquidation of the small river out: closing the water source; clearing of garbage, sediment, vegetation; backfilling the entire river valley.

Following activities are carried out with the partial liquidation of a small river: clearing floodplains from garbage and vegetation; the conclusion of the river into the collector; filling the collector with soil; installation of water treatment facilities at the mouth of the river to prevent the destruction of rivers.
4. Results
The article describes an example of a project for environmental optimization of a section of the Yeltsovka-1 River (from Ippodromskaya Street to Krasny Prospekt Street) of the city of Novosibirsk [9, 10].

According to the assessment results, the Yeltsovka-1 River is assigned the fourth integral point, 95% of the length it is silted, the banks is washed out at a speed of 30 cm / year, it dries out for 30-40 days during the year, the water flow decreases by 30%, and it is a strong building density on the floodplains. There is also a complete mechanical change in the floodplain. The combination of these factors creates strong environmental stress [6].

The main sources of the strong environmental stress of the open section of the river are shown in the scheme in Figures 2-4.

Since the Yeltsovka-1 River has a strong environmental stress, it is necessary to take activities to conservation of the river. The following types of activities are offered:

- Creation of a water protection zone, coastal protection strip. A width of a water protection zone is adopted 50 m (according to the Water Code of the Russian Federation). As part of the coastal protection strip, it is necessary to provide barriers to prevent the ingress of untreated surface runoff into the river.
- Liquidation of surface runoff collectors without appropriate treatment. It will prevent harmful substances, sediment and suspended particles from entering the river.
- Mechanical cleaning of the channel from garbage, sediment, felled trees. It will expand the channel cross section, increase the river flow capacity, which will allow the river to better self-cleaning and reduce the amount of sediment in the future.
- Clearing floodplains from garbage, dead vegetation, felled trees. It will save floodplains from the harmful effects of decaying garbage.
- Forest planting along the coast. Forest redistributes moisture, transfers surface runoff to underground runoff, reduces moisture evaporation and protects slopes from water erosion.

After all of the above activities, it is necessary to carry out environmental rehabilitation of the river. This requires the installation of sediment ponds and hydro-botanical platforms [4].

Sediment ponds are planned at the beginning of an open site and on a stream tributary. After filtering dams, a hydro-botanical platform is established, which is inhabited by hydro-bionts: plankton, mollusks and higher aquatic and near-water plants. In Western Siberia lake reeds, elodea, hornwort, etc. are used for these purposes. To reduce the "blooming" of water due to direct sunlight on the water surface, the environmental rehabilitation project provides for the planting of aquatic plants with floating leaves: a capsule (nymph), varietal water lilies (nymphaea), and floating water lilies. The scheme of hydro-botanical platforms is shown in Figureure 5.

Figure 2. The scheme of the main sources of the strong environmental stress: 1 – untreated sewage collector, 2 – untreated surface runoff, 3 – coast erosion.
Figure 3. The scheme of the main sources of the strong environmental stress: 4 – the garbage on floodplains and in the riverbed.

Figure 4. The scheme of the main sources of the strong environmental stress: 5 – silted zones of the river bed.

Figure 5. The scheme of hydro-botanical platforms: 1 – sediment pond, 2 – filtering dam with spillway, 3 – hydro-botanical platform, 4 – spillway dam.

Thus, it is proposed the use of activities for the conservation of the floodplain-channel section of the Yeltsovka-1 River. As a result of the proposed activities, environmental stress should be reduced. And later this section of the Yeltsovka-1 River can be used as a recreational area for the rest of the population, which will increase the attractiveness of a nearby residential area.
5. Conclusion
In modern socio-economic conditions floodplain-channel complexes, being part of urban areas with varying degrees of urbanization, have urban planning and natural-landscape potential, the implementation of which can be more effective in the situation of integrated strategic planning

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