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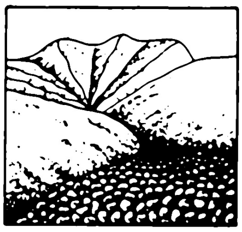

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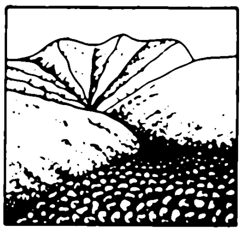

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Debris flows and protection of quality of water resources (case study of Georgia)

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Сели и защита качества водных ресурсов (на примере Грузии)

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Статья посвящена очень важной проблеме сегодняшнего дня – вопросу рационального и полномерного использования ресурсов пресных вод и защите их качества. В работе приводится расчет количества ресурсов пресных вод на единицу площади земной поверхности и сделан соответствующий анализ для территории Грузии. Особое внимание уделяется защите качества ресурсов пресных вод в селеносных водосборных бассейнах. Предложены уравнения для расчета некоторых прогностических гидрологических характеристик и представлены соответствующие рекомендации по защите экологической безопасности водосборных бассейнов.

The present work deals with an urgent problem of the contemporary world - the rational and purposeful use of freshwater resources and preservation of their quality. The reserve of freshwater stock per unit surface area has been calculated and analysed for Georgia. Special stress is put on preservation of water quality in water catchments of debris flow type threatened by natural hazards. We suggest formulae for the calculation of prognostic values of some hydrological indices. We also present measures of ecological safety to be implemented in the catchments of debris flow type.

Today, in the epoch of global warming, the issues of rational use of water resources, maintenance and management of their quality acquire an exceptional significance. Of water resources special attention is oriented to the preservation and protection of quality of freshwater resources. It is well known that water comprises 2/3 of all organisms living on the earth. The famous German physiologist Emil Dubua Rheiman was right saying that “life is animated water” (Derpholz, 1979).

As is known, a total area of the earth’s dry land makes 149×10^6 km^2 and the stock of freshwater resources of the planet amounts to 35.029×10^6 km3 (Yakovenko et al., 1989). It is necessary to outline here that the freshwater resources are unevenly distributed on the earth and a significant part of them is inaccessible for practical use. Due to this some regions of the earth are lacking freshwater resources up to present. UN experts suppose that more severe water deficiency is anticipated during the nearest 50–60 years, when the world population attains 7 billion. So, all necessary measures should be undertaken immediately to maintain freshwater resources. This significant problem is common to all mankind.

Fortunately Georgia doesn’t experience deficiency of freshwater resources. If this stock of freshwater is rationally used and satisfactory quality is maintained, the threat of its deficit will not appear in the nearest future. There are nearly 26 thousand big and small rivers in Georgia and, on the whole, with other water resources the entire stock of freshwater makes 101.87 km^3 (Iordanishvili, 2005). If we add to this stock the underground freshwater, the total value amounts to 107 km^3. It is known that the entire territory of Georgia makes approximately 70000 km^2. It seems that the stock of freshwater reserve makes nearly 0.0015 km^3 per 1 km^2. If a significant part of water resources of the globe is considered inaccessible (Antarctica, Greenland and others), the stock of practically applicable water reserves per square km in Georgia seems to be much higher than on average on the earth.

The 65% of freshwater resources of Georgia falls on the river water. In case of rational and purposeful use of freshwater stock even export of water can be accomplished. It should also be noted that hydro resources of the country are sufficient to provide Georgia with electric power and export it abroad. Proceeding from this, it is necessary to take care of the stock of water resources and do not alienate it. As the circulation of blood in vascular system is led by the sole organ – the heart, similarly all water resources should be managed by a single owner. This function should be accomplished by the state, otherwise a lot of unsolved problems may arise in the management of water resources and it will be complicated to find the causes for the created situation. Such problems may cause contradictory situations not only within the single state, but between several states.

As it was marked above, Georgia is rather rich in reserves of hydro resources, significant part of which falls on mountain rivers. Water flows and severe mudflows are characteristic to this type of rivers. For the study of erosion-mudflow phenomena the following works of some scientists are of special interest due to their significance (Mirtskhoulava, 1998; Morgan, 1955). Nearly 30% of Georgia's territory is of mudflow character and due to the global climate change on the planet this value increases in the recent years. Mudflow processes heavily affect ecological stability of the environment and the quality of water resources among them. Georgia's capital city Tbilisi and its surroundings are mainly supplied with water resources (and especially with potable water) from the catchments basin of the river Aragvi, which tributaries are of mudflow type. From investigations carried out by the Institute of Water Management and Engineering Ecology of Georgia (LEPL Institute of Water Management) it is clear that rivers of Georgia are distinguished with high erosion-mudflow character. This is testified from field investigations on the river Aragvi carried out in the last years (1987-2000) (Gavardashvili, 2002).

Investigation of the effect of mudflow processes on water quality on the example of the river Aragvi allows establishing of those alterations of some indices of water quality, that the mudflow may cause. Mudflow processes are known to increase significantly the concentrations of suspended matter and solid drift in water resources and especially in rivers, which causes the increase of water turbidity. The latter significantly reduces the amount of oxygen dissolved in water resources resulting in the decrease and even disappearance of living organisms. The mudflow-type river Duruji (the left tributary) where fish completely disappeared, is a classical example of the above said. Small left tributary of the river Laskandura (the basin of the river Tskhenistskali) is completely devoid of living organisms. Because of this the river tributary is called "shavi ghele" - black ravine by the local population. "Black" means that such rivers are extremely turbid and mudflow processes are characteristic for them. By the way, the term "Black Duruji" appears in catchments basin of the river Duruji as well, where numerous erosion hearths appear. High turbidity is characteristic also for the Shavi (Black) Aragvi - one of tributaries of the river Aragvi, which interflows with Tetri (White) Aragvi in the settlement of Pasanauri. But in this case water turbidity is connected with geological structure of the basin. River basin is built mainly with clay shale of Liosses age, which are characterized by the high exhaustion index, are easily washed-off by water and exactly this is one of the causes of high turbidity of the river (Tsereteli, 1976). Some works of authors of the present paper deal with urgent problems of water quality (Diakonidze, 2005 a; Supatashvili et al., 2003).

Mudflow processes, except the effect on the ecological stability of the environment often are the source of pollution of water resources. This is caused by the fact that in mountainous regions, poor in useful grounds, population is settled immediately in river gorges, alongside the river-beds. Here different domestic amenities are situated: toilets, poultry-yards, houses for domestic animals, etc. In mountainous regions pastures are situated also, where great number of domestic animals is kept (cattle, pigs, sheep, horses, etc.), causing pollution of these places. After passing water floods and mudflows streams, everything is carried away and together with big amount of solid drift and different detrimental substances brought immediately into water resources, causing their pollution with different inorganic substances. The problem is aggravated by the absence of sewerage system in the settlements (the settlement of Peasantry and other densely populated localities) and the polluted sewage waters without any purification fall into the river Argali. It should be noted that cattle urine contains up to 47% of nitrogen. Investigation of the effect of mudflows on water quality in water catchments of the river Aragvi has shown (Diakonidze, 2005 a) that mudflow streams often arise on the tributaries of the river Tetra (White) Argali and even on several tributaries simultaneously. On some tributaries different kind mudflow streams pass several times a year (rivers Mletiskhevi, Naghvarevis Khevi and others). It should be outlined that Zhinvali water reservoir is fed by the resources of the river Aragvi. Proceeding from the above, we have made an attempt to analyze the problems anticipated on the Zhinvali reservoir as a result of mudflow processes.

Water resources of Zhinvali reservoir are known to be the main source of water supply for Tbilisi and its surroundings. According to the project, total capacity of the reservoir at the mark of 810 m makes 520×10^6 km^3, dead-storage capacity at the mark of 770 m makes 150×10^6 m^3 and useful capacity is 370×10^6 m^3. The projected index of the siltation of the reservoir makes 60 years. Presumably these forecasts are made taking into consideration an average value of the solid drift. But in our opinion, all the hardly prognosticated problems, which the mudflows streams may cause in the basin, are omitted in these estimations. Particularly in the last years, in the epoch of global warming, when the results of frequent mudflow phenomena and expansion of their scale are evident, mudflow streams may arise on several tributaries at once, thus increasing significantly the volume of solid drift. Before the construction of Zhinvali reservoir the drift, formed in the catchments basin of river Aragvi was transported without significant problems to the river Mtkvari (Kura). Due to this the turbidity of the river Aragvi (except Shavi Aragvi) was high only at water floods and particularly at the formation of mudflows. After the construction of Zhinvali reservoir, significant deal of solid drift was sediment into the reservoir thus reducing siltation time of the reservoir. But besides that together with the increase of turbidity of the reservoir the amount of water-dissolved oxygen significantly decreased in it. Proceeding from this, inhabitants of the river (fish, other living organisms and micro flora) are under the threat of disappearance. It seems that regulation of water resources of the river Aragvi by means of water reservoir constructed on it is of positive economic significance on the one hand, but on the other hand it can evoke undesirable results like sedimentation of great amount of solid drift in the reservoir. This increases significantly the threat of reduction of living organisms in the water.

All the above mentioned indicates that it is necessary to continue investigations aimed at studying erosion-mudflow processes in catchments basins of erosion-mudflow type in order to prognosticate mudflow processes. This will allow designing anti-mudflow measures, to avoid the anticipated ecological problems and protect water resources from the pollution.

Obtained by as the following empiric relationships can be used to establish average value of solid drift for the catchments basin of the riv. Aragvi (Diakonidze, 1980, 1982, 2005 b; Rostomov, 1980):

for calculation of suspended drift:

$$\overline{R} = 0.0000022\ N^{2.71} \qquad (1)$$

where $\overline{R}$ is the average long-term discharge of the suspended drift (kg/sec), N – basin capacity (Wt), calculation method of which is given in [5, 6, 11].

Total solid drift can be calculated by the formula

$$\sum (\overline{R} + \overline{G}) = 0.0000052\ N^{2.70} \qquad (2)$$

where G is the average long-term discharge of the bottom drift (kg/s).

For calculation of mudflow discharges is offered empiric formulas which are obtained from the relationship between potential capacity of catchment basins and mudflow discharge (Diakonizde, 2005 b):

$$Q_{mudfl.1\%}=0.06N+2.0\ (m^3/s),\ \text{when}\ N\leq 1000\ \text{mil. Wt.} \qquad (3)$$

$$Q_{mudfl.1\%}=0.08N+45\ (m^3/s)\ \text{when}\ N\geq 1000\ \text{mil. Wt.} \qquad (4)$$

In these expressions $Q_{mudfl.1\%}$ is a turbulent value of mudflow provision in m^3/s, the basin capacity N is calculated according to 1% provision of water discharge.

The following **measures** seem to be advisable to preserve water quality in mudflow type rivers and maintain maximum admissible concentrations of standardized substances in them:

1. Regular testing of water samples, their monitoring and analysis in order to establish quality indices of mudflow-type water currents.

2. Arrangement of sewer net in densely populated settlements. Construction of new system in those localities, where the sewerage system is absent.

3. Adjustment of toilets and animal houses to sanitary standards.

4. Strict regulation of all construction activities on the territory of catchment basin in accordance with elaborated and proved projects.

5. Reducing standardized substances in sewage waters to the boundary admissible concentration.

6. Strict observance of safety regulations at transporting of freights (especially oil products and other harmful substances) in order to avoid pollution of water resources.

7. To provide maintenance of water quality, strict nature-conservative measures should be accomplished. In our case it is necessary to built sanitary zones to preserve Zhinvali reservoir and the territory adjoining to it where animal grazing and other domestic activities will be prohibited to avoid the threat of water resources pollution. It is desirable to assign the status of reserves to such sites.

8. Investigations conducted in Georgia in the regions being under the mudflow threat (basin of the Aragvi river) have shown that mudflow torrents heavily contribute to the high turbidity indices of water resources. It has also been established that the concentration of suspended matter and correspondingly its mineralization on the Aragvi river is much higher above the water reservoir than below it. This seems natural, as the reservoir is a kind of a huge collector, where a significant deal of the suspended drift is sediment. After a certain time this may cause reduction of oxygen concentration dissolved in water due to the silting of the reservoir that may threaten living organisms and fish resources.

9. Due to the mentioned circumstances it is necessary to accomplish anti-mudflow measures on those water-ways of mudflow-type, where the mudflow currents are formed several times a year threatening local population, industry and quality of water resources.

10. It is necessary to continue anti-mudflow investigations in such regions to prognosticate the mudflow phenomena, which is essential necessary for the realization of any construction projects, designed against mudflows.

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