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Water Quality Monitoring and Geospatial Database Coupled with Hydrological Data of Zeravshan River Basin

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Abstract: This paper focuses on water quality monitoring of the main streams, irrigation canals, collector-drainage system of Zeravshan River Basin and on developing a platform for efficient data management and sharing of water quality and hydrological datasets. The water quality monitoring had been carried out from 2005 to 2010 throughout the basin and collected water samples, hydrological, meteorological and economic data indicate that generally water in the downstream part of the basin was in significant low quality. The water contains high concentration of salts and heavy metals that could be dangerous for people livelihood. The water quality datasets are stored in a newly developed web-based geospatial database, coupled with hydrological data collected during many years. The database integrates quantitative and qualitative datasets into spatially-explicit maps which help intuitive data handling and easy sharing for collaboration work. The web-based feature of the database with online access to the visualized maps of hydrological and water quality datasets provides an interactive framework solution for collaboration among those involved in water resources management in Zeravshan river basin.

Key Words: Central Asia, Hydrological data, Water quality, Web-based platforms, Zeravshan River

1. Introduction

Zeravshan river basin is the origin place of the agricultural and urban civilization of Central Asia and is the main source of potable water for the Zeravshan valley, one of the highest populated area in Uzbekistan, with population density around 80-100 people/km^2. Among Central Asian rivers Zeravshan river basin is profoundly affected by mismanagement of the water resources, due to the huge diversion of irrigation and drainage network to the crop fields, as well as water losses in a result of soil infiltration and evaporation. The amount of water diversion for irrigation is almost equal to the total water flow of the river. Moreover, the stagnant and conventional agricultural irrigation practices induce high accumulation of toxic salt, heavy metals, biogenic and other types of pollutants in soil, plants, surface and drinking water (Tsukatani and Katayama, 2001, Toderich *et al*., 2005).

Inefficient use of water for irrigation coupled with inadequate maintenance of drainage systems caused land degradation and water quality deterioration, mostly appeared in downstream areas. Water quality of Zeravshan river basin being significantly contaminated in the downstream can be even worse under frequent droughts that may be intensified by climate change in the Central Asia. Severe droughts of 2001-2002 and 2007-2008 serve an evidence supporting occurrence of devastating climate change and glaciers-snow melting impact (Agaltseva, 2002). Low quality of water raises economic and social burden due to increased incidents of health problems (Fayzieva, 2004, Saito, 2010).

Planning and management strategies for water resources systems in this basin face another problem - data scarcity. The problem is caused by decreased number of active stations in the gauging network, because of reduced funding and political tension on water issues between countries sharing the basin.

To mitigate the problem the authors had collected a large amount of datasets related water environment in this region from 2005-2010 years. This collection of datasets can be useful not only for researchers but also local communities to investigate better water management. Additionally easy access and handling of the datasets supported by a user-friendly data repository will intensify an efficiency of collaboration work. This idea served as a motivation to develop a platform for data repository with online access and sharing functions of hydrological information (Khujanazarov *et al*., 2011). The platform can be used individually and collectively; a single user can use it as a workspace and a group can develop its own database storing collected datasets with geospatial visualization or use it as a collaboration space.

The goal of this study is 1) to show the monitoring results of water quality in Zeravshan river basin, and 2) to develop a well-structured and easily accessible database of the water quality datasets coupled with hydrological data, for better

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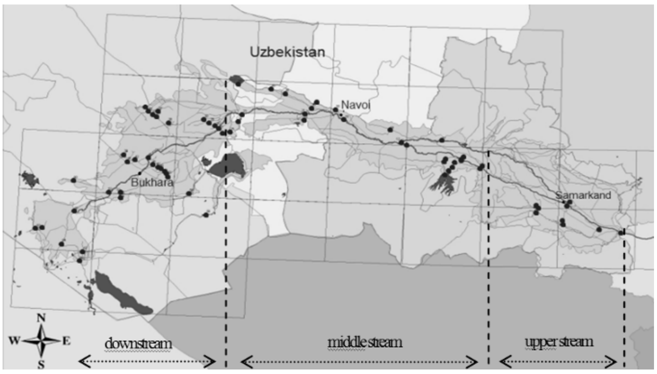

Fig. 1. Zeravshan river basin. Black dots are sampling sites.

communication on water resources management of this basin.

2. Water quality monitoring

2.1. Methodology

The authors have performed water quality monitoring and assessment from 2005 to 2010 along Zeravshan river in Uzbekistan. The river network is divided into three large parts: upper stream, middle stream and downstream areas. From 74 sampling sites along the river course from the main channel and its tributaries, canals and drainage collectors water samples had been collected (**Fig. 1**). The monitoring points are located over the basin allowing spatial and statistical analysis of water distribution. The monitoring was accompanied by hydrological and meteorological observations as well as soil and plant chemistry analysis. At each sampling site pH, electronic conductivity (Ec), turbidity (Tur), dissolved oxygen (Do), water temperature (T) and total dissolved salts (TDS) of river water were obtained by Horiba multiple water quality monitoring system as U-10; LMO or U-20, Meter TOLEDO, ATAGO. The samples ware processed by HP 4500 inductively coupled plasma mass spectrometer (ICP-MS) to detect substances found in river and drinking water.

2.2. Water quality monitoring results

The monitored datasets show that water quality of the upper part is significantly different than that in the lower reaches of Zeravshan river valley. Results showed that the river water consists of a variety of salts such as chlorides, of calcium, magnesium, biogenic elements and radionuclide with high concentration especially in the downstream area. Down the stream from mountains to Navoi city average mineralization increases from 0.3 to 1.5 g/l and then in Bukhara oasis it reaches 2.8 g/l. Mineralization level of water in the collector and drainage, broadly used in Bukhara oasis, is higher and ranges from 2.5 to 4.9 g/l. Lower mineralization (0.6-0.7 g/l) occurs in canals of which water is taken from the Amu Darya river and is used for irrigation and partially for potable

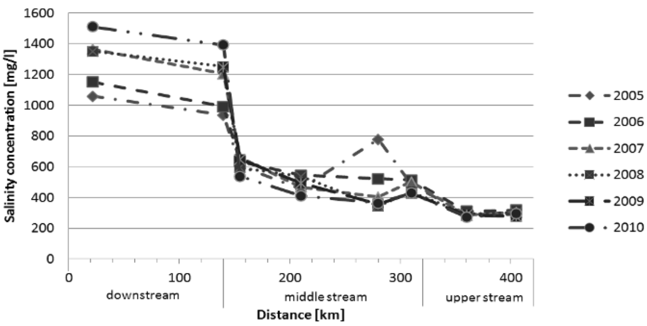

Fig. 2. Water salinity level along Zeravshan river (2005-2010).

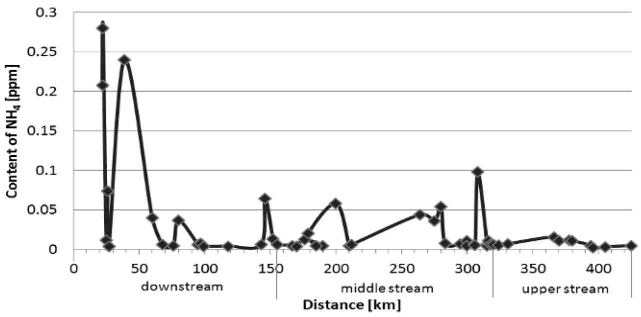

Fig. 3. NH_4^+ contents observed in year 2010.

water supply of Bukhara region.

As shown in **Figure 2**, salinity level generally increases as it goes towards the downstream. It is mainly due to of the salt load in the return flows from irrigated areas discharged via the collector drains, which are usually poorly maintained. In the lower reaches of Zeravshan river basin there have been significant increases in mineralization of water and soil over the time because of the expansion of irrigated agriculture. The increased salinity level is mostly caused by leaching practice of irrigation and accompanied decrease of river water discharge to the downstream in the last decade.

Surface water from different sources in Bukhara oasis and a part of Karakul plateau (lower reach of Zeravshan river) is also contaminated by discharges from sewage treatment facilities. The extent of non-point pollution from a growing number of livestock has shown only a slight increase on total dissolved salts (TDS), ammonium and other nitrates in water samples of surveyed area. The maximum value of nitrates in the water was recorded in late autumn-winter seasons. The ammonium NH_4 concentration, shown in **Figure 3**, within the investigated area of the basin from Tajikistan border through Bukhara oasis into Kyzyl-Kum sandy desert, can be used as a bio-indicator of the sanitary state of surface and underground water. The gradual accumulation of NH_4 ions could be due to water pollution caused by communal and agricultural wastes or artificial water management in the desert areas.

According to the monitoring results, Zeravshan river water also contains traces of some heavy metals that exceed the

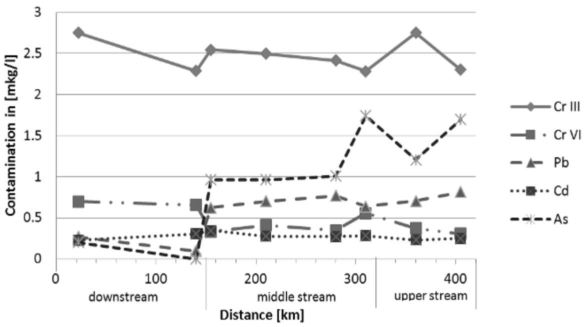

Fig. 4. Water contamination by heavy metals (2007).

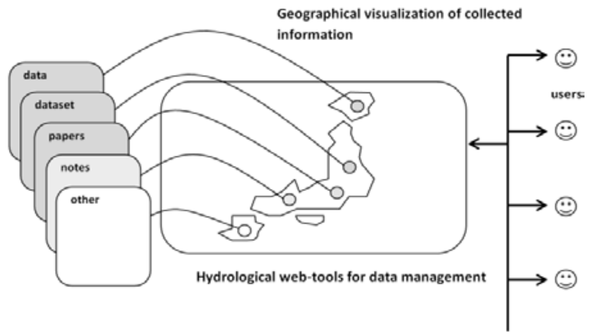

Fig. 5. Design philosophy of the platform. (Khujanazarov *et al*, 2011).

guidelines proposed by World Health Organization and Food and Agricultural Organization. The traces of lithium -Li^{7} (8.67 - 691.8), chromium -Cr^{53} (7.45 - 100.5), strontium -Sr^{88} (378.8 - 11780) and lead -Pb208, arsenic -As^{75} and others were frequently detected in the water samples (**Fig. 4**). The impact of heavy metals on health of the local residents must be thoroughly studied; especially the transfer of heavy metals through food, freshwater and through natural ecosystems chains (Khujanazarov and Tsukatani, 2007).

3. Developing geospatial database of Zeravshan river basin for effective data management

3.1. Motivation

Initially when the water quality monitoring was started, the collected datasets were stored in GIS maps mainly consisting of three layers of hydrological, chemical and meteorological data. The GIS maps allowed for creating a digital coverage of the irrigated agriculture area of Zeravshan river basin, which was used as a template for further mapping of physical and chemical water parameters. The results of chemical analysis were also transformed into digital GIS maps. These maps gave a great opportunity for visualized preview of study results, providing highly informative view on the research area.

During monitoring years, however, the amount of collected information has been growing significantly and it ranges a wide variety of dataset types as well. Currently, the collected datasets include not only monitored chemical data but also hydrological, economical and social data for almost entire area of the basin covering many different aspects of river and basin infrastructure, extending to the upstream parts of the basin. These datasets can be very useful not only for researchers working in the basin but also to the local communities. The previously used approach (GIS maps) was very usual for datasets handling; on the other hand, these solutions failed to provide a simple and effective way for sharing datasets with communities, and to organize well a growing amount of dataset files. The task for managing and storing datasets in an easily accessible repository platform forms a vital portion of the study. This initiative lead to the development, by some of authors, of a web-based hydrological platform aimed to create a collaborative, comprehensive data storing system that can provide interacting possibilities with available datasets.

Figure 5 shows design philosophy of the platform, which uses combination of geographical maps with a whiteboard for magnet pinning in association with hydrological tools. Pinning a dataset on a specified place helps to organize a dataset library on the map and move from a large list of files to the visualized maps of obtained data (Khujanazarov *et al.*, 2011). The platform is web-based and aimed to share open data among those who are interested, especially at the areas with information scarcity problem. It is a simple tool to map, store, search and share datasets collected though different research activities, in order to manage a large amount of datasets. The platform is based on open source web solutions, and its geospatial visualization is provided by Google Maps API. Google Maps API provides geographical maps, and most its API functions can be used in the platform, such as map zooming, choosing satellite images and others.

3.2. Zeravshan river database developed on the platform

The datasets monitored in Zeravshan river basin have started to be stored in the platform (**Fig. 6**). Currently the datasets on water quality analysis from 2005 to 2010 for each year and average monthly discharge data obtained at gauging stations from 1970 to 2000 for 20 stations have been pinned on different map layers. These layers are for salinization, nutrient pollution, heavy metals pollutions and hydrological data. Each point on the map layers is assigned to the sampling site or gauging station and these points are attached with files of collected information. The platform automatically recognizes different data file types and shows the points with different marker icons corresponding to the data file types. This function provides visual interpretation about what type of data is available on the map layers.

The datasets were added to the platform by simple mouse click on the maps or by importing them from a list formatted as an excel spreadsheet. Because the datasets are already

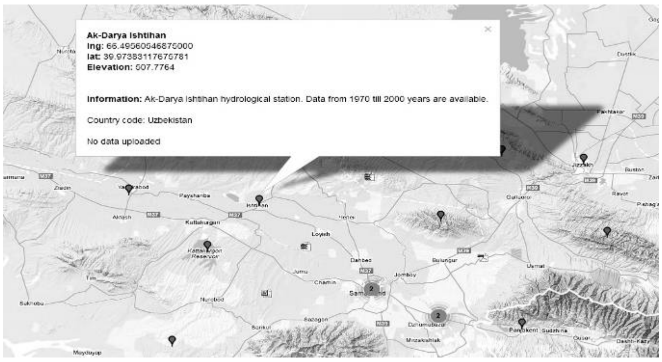

Fig. 6. Map of Zeravshan river basin with pinned data source.

uploaded and stored on the platform, a user is freed from arranging them. The applications provided by the platform are responsible for managing datasets, while notes and keywords for the datasets are used as anchors to find them. One of the advantages of the database is an easy integration of unstructured, sparse and diverse datasets from different sources into a data repository with simple visualization. A wide variety of information and data resources from various sources with different background can be added to the database and will increase its potential for broader use.

The platform provides several ways of searching datasets; a user can find a desired dataset by filtering data types and searching with specified keywords through notes or given descriptions. The platform also provides catchment delineation, which facilitates data spotting for a target catchment. It can be used with filtering and searching. Combination of filtering, keyword searching and catchment delineation can even more effectively narrow down the output results. The found data files can be downloaded from the pop-up window of each point.

Another advantage of the database built on the web-based platform is easy sharing of diverse datasets through the internet. It can provide not only individual researchers with a visualized desktop application of available datasets or dataset repository solution, but also researchers working in big projects with benefits of an integrated collaborative working environment based on visible maps of collected datasets coupled with useful hydrological functions.

Currently water quality and hydrological data of Zeravshan river basin are accessible to the users. The database will continue to grow gradually with ongoing water environment monitoring and accumulation of activities for better water resources management in Central Asia including Zeravshan river basin.

4. Conclusion

The monitoring results show that water quality, especially in downstream area is subjected to serious pollution. Salinity trends and water pollution management in Zeravshan river basin mostly in the downstream of the river should be further checked for regional water quality control. Maintenance and sustainable use of water resources should be monitored and paid great attention. Improvements in irrigation system, which also include functioning of drainage collector network to insure water quality and reduce impact of salinity in return flow from irrigated land should be considered.

The developed Zeravshan river basin database can be a helpful reference to find solutions of a wide range of arising problems in planning water management through available information and datasets. It provides a simple tool to share collected information, which can be important in the poorly observed area. Providing the datasets through the web-based platform will help in building a centralized data repository for this basin. Visual representation of the datasets on maps will facilitate sharing them among interested local communities and researchers. The database will continue to grow with the accumulation of information, datasets and knowledge acquired by research activities and practices of better water resources management for the basin.

References

Agaltseva N. (2002): The assessment of climate changes impact on the existing water resources in the Aral Sea Basin. *Dialogue about water and climate: Aral Sea as a particular case*. Tashkent: Glavgiromet, pp.3-59.

Fayzieva D.Kh., Atabekov N.S., Usmanov I.A., Azizov A.A., Steblyanko S.N., Aslov S., Khamzina A.S. (2004): Hydrosphere and health of population in the Aral Sea Basin. In: *Environmental Health in Central Asia: The Present and the Future*. Southampton: WIT Press, pp.51-100.

Khujanazarov T.M., Tsukatani T. (2007): Application of GIS technology for water quality control in the Zeravshan River Basin. *Carbon Management and Sequestration in Drylands of Central Asia*. Netherlands: Balkema Publishers, pp.419-429.

Khujanazarov T.M., Ichikawa Y., Magome J., Oishi S. (2011): Development of the web-based map-oriented workspace platform for storing and sharing hydrological data. *Annual Journal of Hydraulic Engineering JSCE*. (in print)

Saito L. (2010): Using Stable Isotopes, Passive Organic Samplers and Modeling to Assess Environmental Security in Khorezm, Uzbekistan. *Final Report, NATO Science for Peace Project No. 982159*, pp.39.

Tsukatani T., Katayama, Y. (2001): Baseline Study of Surface Streams of Zeravshan River Basins. *Discussion Kier Paper. Joint Field Survey Expedition*, 528. University, Kyoto, Japan, pp. 68.

Toderich K.N., Tsukatani T., Shuyskaya E.V., Khujanazarov T., Azizov A.A. (2005): Water quality and livestock waste management in the arid and semiarid zones of Uzbekistan. *Proceedings of the University of Obihiro*, pp.574-583.