# Introduction of a new method of measuring the water level when creating a digital monitoring system of the Baikal water area

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**Abstract.** In this article, the solution of the tasks of monitoring the Baikal natural water area is supplemented by the introduction of a new method of measuring the water level. This method is aimed at solving current problems and tasks that arose earlier in the development of a digital monitoring system.[1-2] The transition to a new measurement method will improve the accuracy of measurements, calculate both the average level of the entire Lake Baikal and the local level in certain regions of the lake. The possibility of radio-channel data transmission makes it possible to capture data in remote areas of Lake Baikal. Our own innovative method of measuring the water level is characterized by a simple setup and calibration of the sensitive elements of the device, which allows you to set the required number of monitoring points throughout Lake Baikal. The introduction of a new measurement method will create a budget monitoring system that is not inferior to foreign analogues.

## 1 Introduction

The digital monitoring system of the Baikal water area should solve a number of tasks, one of which is to measure the water level with high accuracy. The development of a new method for measuring the water level will make it possible to abandon the introduction of foreign measuring systems and other similar solutions, which, ultimately, multiply both the cost of implementing the system and subsequent maintenance[3].

The method of measuring the water level proposed in this article has no analogues and differs not only in budget, but also in high measurement accuracy.

The purpose of the work. This work is devoted to the modernization of the digital monitoring system of the Baikal water area, through the introduction of a new method of measuring the water level.

At the moment, there are several hydrological posts on Lake Baikal that use foreign equipment for data collection[1]. Due to the high cost of such equipment, the total number

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of open monitoring points does not meet the requirements of institutes studying Lake Baikal.

For example, the MIDAS SVX2 hydrological probe manufactured in the UK as of 2020 cost 767,401 , MIDAS CTD+ from 480,000 , the American CTD SBE 49 FastCat probe from 300,000 . Therefore, the current market situation does not allow creating a budget network for monitoring hydrological parameters.

As part of the implementation of the scalability property of the digital monitoring system, a new, more budget-friendly method for determining the average water level of open reservoirs was proposed, for which an application for a utility model has currently been filed with the patent office.

The main task of the new method is to determine the average water level of natural reservoirs in summer and winter. The method will allow registering transverse waves and seiches in the lake, tracking the movement of atmospheric fronts, registering the impact of earthquakes and the possibility of their prediction, registering other natural phenomena on the water.

The recording device consists of the following components:

1)Sensor element,

2)Interface converter (to work with a radio modem),

3)Radio modem (for data transmission),

4)Power sources (battery, solar cells),

5)Antenna,

6)Body.

The Infineon DPS368 sensor was chosen as a sensitive element, which is characterized by high measurement accuracy and low power consumption.

The high accuracy of such sensors makes it possible to record changes in atmospheric pressure with a small movement of the sensor along the height.

Thus, a new method of measuring the water level based on atmospheric pressure readings was proposed.

## 2 New measurement methods

The principle of the new method is as follows:

Initially, the sensors are pre-calibrated at the same height, which can be performed both in laboratory conditions and directly in the field, near the lake area.

The purpose of this calibration of the sensing elements is to minimize the measurement error, namely the pressure difference during subsequent mathematical operations on the information measuring server.

After calibration, one of the sensors is installed at the ground station, which is a reference atmospheric pressure sensor and is taken as zero in calculations.

A measuring buoy with a second recording sensor is installed in the reservoir, which measures the current value of atmospheric pressure on the water.

When the water level in the reservoir changes, the recording sensor records this change by means of constant monitoring of atmospheric pressure and transmits this data to the ground station via radio channel.

After that, the data obtained are recalculated and used to determine the average water level in the lake according to the following formulas and ratios.

$$P=Pg-Pv, \tag{1}$$

where Pg is the value of atmospheric pressure on the shore (hPa), and Pv is the value of atmospheric pressure from the sensor in the reservoir (hPa).

Thus, the total atmospheric pressure is compensated, and only the difference between the sensors on land and on the water is taken into account.

After that, the obtained value of the pressure difference is converted into the liquid level according to the ratio:

$$1\ Pa = 0{,}087\ m\ (8.7\ cm). \tag{2}$$

All mathematical operations are performed only on the server, since processing them directly at the coast station will take more time, impose additional computational loads and power requirements on microcontrollers, which will ultimately increase the cost of the finished device and the entire measuring system as a whole.

At the moment, the transmission of telemetry data from the measuring buoy to the ground station is limited to a range of 23 km, which is already enough to solve most problems of monitoring the water area of Lake Baikal.[2,5]

A diagram of the new water level measurement method is shown in Figure 1.

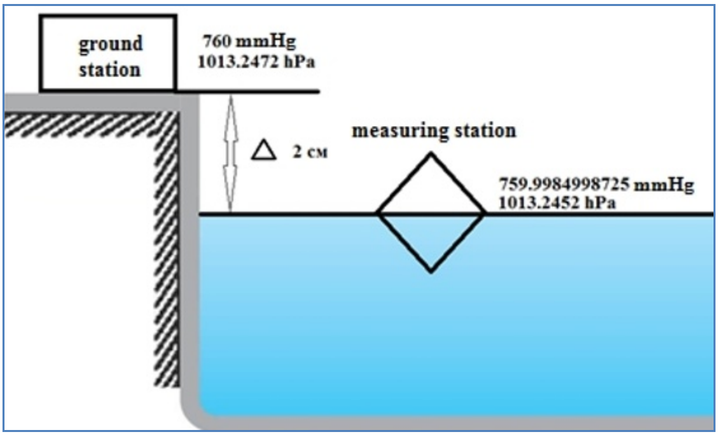


**Fig. 1.** Water level measurement method.

The flow diagram of the sequence of actions when measuring the water level is shown in Figure 2.

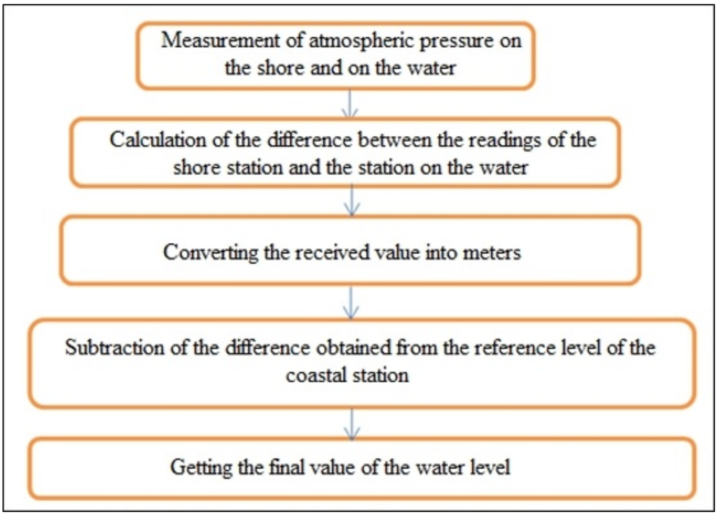


**Fig. 2.** Measurement sequence algorithm.

## 3 Conclusion

The proposed information and measurement system is a reliable and low-cost tool for collecting, transmitting and processing information within the framework of creating a unified state environmental monitoring system and a local monitoring system for the coastal zone of Lake Baikal and the Baikal territory.

The introduction of this system will contribute to the formation of a common array of data for the compilation of environmental maps, the development of geoinformation systems, modeling and forecasting of environmental situations, the use of the data obtained for scientific purposes and in current calculation methods for energy facilities.

The use of a new method of measuring the water level will allow obtaining data on the entire water area of Lake Baikal, including remote areas where there are problems with cellular communication.

The proposed new measurement method will make it possible to evenly install the required number of monitoring points throughout the lake.

When a sufficient number of automatic stations are put into operation, it will be possible to increase the accuracy of calculating the average daily level with the determination of new weighting factors for taking into account the impact of each station.

With sufficient integration of additional stations across the entire water area of the Baikal natural territory, it makes it possible to take into account the territorial (local) change in water level.

Synchronization of telemetry data will allow to increase the reliability of calculation methods used in institutes to determine the average level of the lake, including its daily value for operational regulation of discharges of the Irkutsk hydroelectric complex.

Combining the efforts of various departments and scientific organizations within the framework of a unified environmental monitoring system will allow us to develop an integrated approach to monitoring the environment and the coastal zone of Lake Baikal and the Baikal territory, use a single database of accumulated data in the interests of various departments and scientific organizations, significantly reduce the total cost of conducting research.

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