# Development of a Radioactive Precipitation Monitoring System Based on Wireless Technology Training

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## Abstract

Disadvantages of existing monitoring system are critically analyzed. It is discussed, when monitoring systems can bring failures to radiological measuring process. It is considered how to get the best performance for working monitoring system by using wireless technologies. Two types of wireless technologies are suggested to use for developing new generation of monitoring system, namely internet of things (IoT) and wireless electric power transfer (WPT) through satellites.

**Keywords:** monitoring system, radioactive precipitation, measuring sensor, wireless technologies.

## 1 Introduction

The purpose of radioactive precipitations (RP) monitoring is observation and controlling radiological situation of territory under research to get the basic information for the territory estimation and prognosis. Matter of the radioactive precipitation monitoring system (RPMS) is direct and regular observation and field measurements (or, measurements in-vivo), which are carried out on territory of some locality to extract information about radiological characteristics of environment. Using data of RPMS gives an opportunity to reveal the laws of the locality radiological situation changes. This information is required to make a conclusion about radiological status-quo of: a) people in the locality, b) nature, and c) animals. The last two factors form a food security and the radiological ID, which lead to making a decision for concrete radiological situation.

Above-mentioned tasks of RPMS are resolved, as a rule, by three main technical components:

- Out-door terminals of radiological control located in fixed geographical locations, which periodically, accordingly to the technical requirements, make measurements;

- Observation (or controlling) network for environment components, which contains equipment's for receiving, treatment and transfer of information as well as antenna equipment and UPS; and
- Mobile terminals of radiological control, which are used for making measurements in randomly selected points.

For example, one can provide some data for existing RPMS. On territory of the Republic of Belarus in 2020, there are 76 our-door terminals for radiological monitoring of atmosphere [1], which have been distributed as:

- 41 observation terminals for daily measuring power of γ - radiations;
- 25 observation terminals for measuring precipitations from atmosphere onto the Earth's surface (the samples have been selected daily by using horizontal tablets at 7 terminals located in areas close to Atomic Power Plants (APP), and once in 10 days at remaining 18 terminals);
- 10 observation terminals, which have been located in 10 different sites scheduled for measuring radioactive aerosols at near-Earth surface atmosphere (the samples have been selected daily at 9 terminals and once in 10 days at remaining terminal in city Mogilev).

For operative revealing disasters and dangerous situations, daily samples of atmosphere selected from areas near active APP-s have been subjected to analysis for finding short lived radionuclides, especially the isotope iodine-131 (half-life is equal to 8 days; this isotope is estimated to play significant role in nuclear fusions and have very dangerous effect on living organisms). All these terminals were fixed at geographic locations and used for determining tendencies in radioactive fallouts behavior from both local reasons (within country), and exogenous ones (neighboring and remote countries).

It is obvious that for all above-mentioned technical components of RPMS energy and communication facilities are necessary. By this reason, in modern RPMS most of devices and instruments are maintained by back-up source of electricity for uninterrupted work. Only in this case one can talk about completely equipped RPMS.

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## 2 Disadvantages of existing RPMS

The main problem of existing RPMS is based on the fact, that observations in-vivo should be carried out permanently for a long time. Because, namely while long-time and permanent measurements the fluctuations of RP on given territory can be cleared as well as the changing tendencies and their reasons may be determined. For example, in paper [2], radioactive pollutions of river Syrdarya have been studied and it is shown that season fluctuations of the pollutions can vary by amplitudes 7-8 times (see Figure 1). This experimental fact approves an idea that radioactive precipitations measuring on tested territory whole a year is justified.

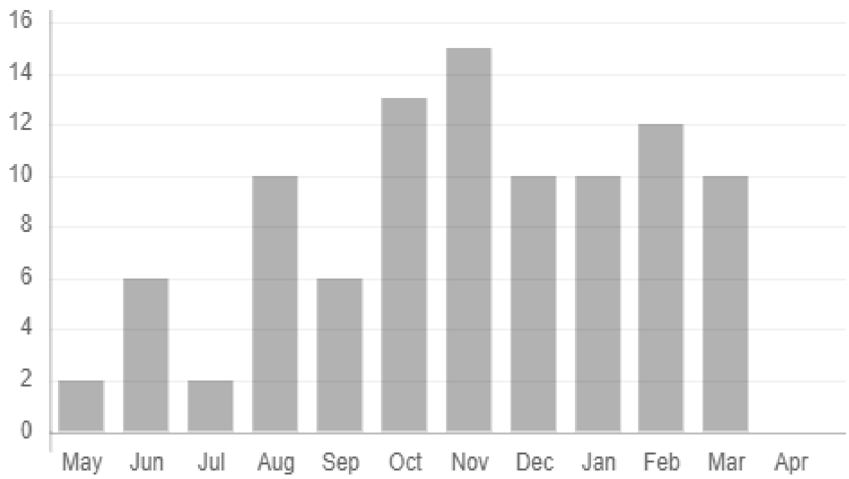


**Figure 1. Season fluctuations of radioactive pollutions in Syrdarya river basin [2]. Values by ordinates are measured in Becquerel/liter (Bq/L).**

The second circumstance, which may strongly affect working RPMS is, testing areas are often placed very far from each other. This leads to great time losses and expenses for making real measurements. For example, in paper [3], authors note that distance between observation terminals may exceed 30 km. There is one more reason for many expenses due to functioning existing RPMS. Any detector and/or sensor, which is the physical base of measuring process, has strictly regulated time interval for energy supply. In other words, detector or sensor will precisely measure the RP level only while the service time of battery (and/or, any other energy source). So, it is logically concluded

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that any RPMS will be valuable only for period indicated in technical specifications for electric energy sources. If battery of detector (or sensor) is running low, then any RPMS loses functionality as a whole. This failure may be partial or full in dependence upon: a) design peculiarities of RPMS, and b) the role of concrete detector or sensor in the RPMS hierarchy. Due to this reason, for maintaining the full functionality of RPMS it is necessary to periodically making check-up and substitute energy sources independently on, where these sources are embedded into RPMS. This, in turn, means the multiply costs and such an exploitation parameters as man working time, sources prices, transportation expenses and so on.

In case, when for making measurements in terms of RPMS it is necessary to use mobile terminals of radiological control, problem of energy supply also becomes important. Obviously, any mobile terminal for radiological measurements as well as measuring robot, manipulator etc., should be supplied by energy. Moreover, this energy is needed for both mechanical moving, and making measurements. And, in urgent cases, when disasters happen and there is necessity to making measurements in occasional and randomly selected locations, problem of energy supply looks absolutely different. Because, one needs to deliver energy in randomly selected geographical location.

In addition, it is worthwhile to underline some technical specifications of working RPMS in field conditions. Electric batteries loss their nominal technical characteristics due to low, or vice versa, high temperatures of environment (thermal discharging), humidity and raining/snowing (oxidation, coating rust) and so on.

Hence, we may conclude that developing RPMS means making observation and measurements by time and geographic location, but full functioning RPMS is possible when all above mentioned components of RPMS are permanently supplied by electric energy. As it follows from critical analysis of working RPMS, the most important criteria for advanced RPMS-s are their ability to work:

- 24 hours and uninterrupted functioning at any meteorological conditions;
- In any geographical location and remote areas when making urgent radiological measurements are necessary but specifications of relief and landscape are complicated.

Finally, we conclude that RPMS of new generation must work at

- The minimal human intervention;
- The minimal dependence upon field and meteorological conditions;

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- The maximal operational independence and self-consistency;
- In addition to above said three points, have an ability to keep their functionality and technical specifications for a long time.

**Using Wireless Technologies**

This purpose can be achieved by application of wireless technologies (WT), thereto these technologies, to our view, have to be classified by two categories:

1. Managerial WT and
2. Energetic WT.

In accordance with our concept for RPMS on the base of WT, managerial WT-s are of internet of things (IoT, well known technology, which is sufficiently widely used in our days, for general information see [4]), but energetic WT-s – electric power transferred wirelessly. Managerial WT-s are data transmission (in general case, any information) between physical objects, which are integrated into one hierarchical chain. RPMS is just one of typical example of this hierarchical chain. Physical and technical aspects of wireless transfer of electric power are discussed in details in recent paper of authors [5]. In this paper, authors considered advantages of wireless transfer of electric power through satellites, which are very fruitful for cases discussed in present paper, namely:

- Independent and autonomous producing electric power;
- Delivering electric power to remote locations;
- Operative supplying by electric power in case of disasters and technogenic hazards;
- Delivering electric power to mobile consumers (devices, detectors, sensors and so on)

and many others. Joint application of both WT-s indicated above will lead to developing RPMS of new generation, namely monitoring system, when:

a) the human factor is practically absent,

б) elements of the system, including observation terminals, mobile controlling facilities, terminals for information gathering and analysis etc., may be distributed on wide area,

в) devices of RPMS for their correct functioning, due to electric WT-s, may be supplied by electric power unlimitedly long time.

Remotely installed measuring devices (detectors, sensors) will transmit current information to local center for information gathering after that, the information received will be transmitted to the main

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center. All the transmitted information is analyzed, treated and generalized, finally we can develop the scheme of optimal radiological status-quo of measured geographic point, area, location and so on. This procedure allows to create the algorithm of resolving radiological force-major, if happens. All the device and centers, transmitting and receiving antennas will be supplied by electric power in terms of electric WT-s.

Wireless technologies training is necessary for optimal relocation mobile radiological stations as well as in case of situational force majeure and/or risks, if such happens at the atomic plants. Now, we are working on developing the algorithm for training optimization.

**Conclusion**

The purpose of current paper is to substantiate a possibility to develop principally new generation of RPMS, when all the managerial and measuring operations can be done by means of WT-s by minimizing the human factor. For implementing this type of RPMS, it is proposed to integrate in monitoring system WT-s as they have been classified above. It is understandable, that many questions are not described herein in detail, and discussed only qualitatively.

RPMS of new generation developed on the base of two WT-s, a) management and b) electric supply, will be more technological, as a result, more effective, less subjected by exogenous factors, and of course low cost. Theoretically, development of RPMS of new generation, as it proposed in this paper, gives an opportunity to build the unified global monitoring system, which could be responsible for radiological situation of air, water, soil and other segments of environment. Such a system will lead to the absolutely new managerial and implementation level of radiological security.

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