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## Ecological Internet Resource as a tool for Information Control of the Harmful Effects of Environmental Pollution

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**Abstract.** The authors consider the feasibility of creating publicly available information resources and services that provide data about an ecological situation and degree of ecological contamination of concrete region. An Internet resource for information support of users on environmental pollution issues, which is based on the Microsoft Bing Maps map service and Silverlight plugin, is described. There was shown that application of given technologies allows to use multimedia, graphic arts, animation and interactivity in one software platform. Text, contained in the Silverlight applications, is accessible for the searching systems. The described application collects data on the ecological state of the environment in a specific region in the amount necessary for its analysis and decision-making on environmental issue.

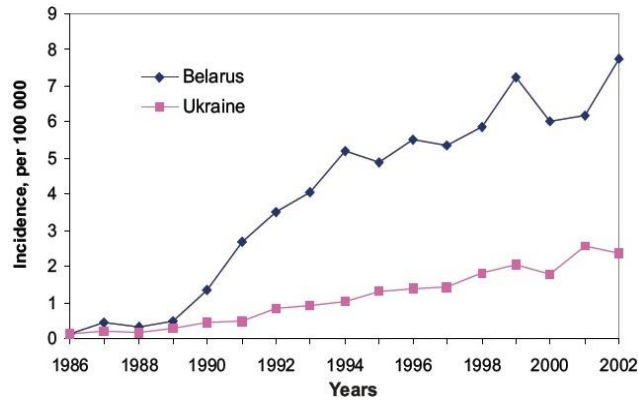
**Keywords:** Ecological state, Environmental, Internet resource, Environmental information, Environmental pollution.

### 1 Introduction

Ukraine is painted black on the UN map due to its environmental deterioration. It is the color of a country where the population is dying out [1]. According to Institute for Demography and Social Studies of the National Academy of Sciences of Ukraine the South and the East of Ukraine – the so-called “Black Belt” – is dying out at a record pace. Environmental problems contribute in no small part to this shocking statistics. According to the State Statistics Service, 72 kg of pollutants fall on each Ukrainian per year [2]. As of 2016, Ukraine is ranked 4th in the world and 3rd in Europe in terms of mortality [3].

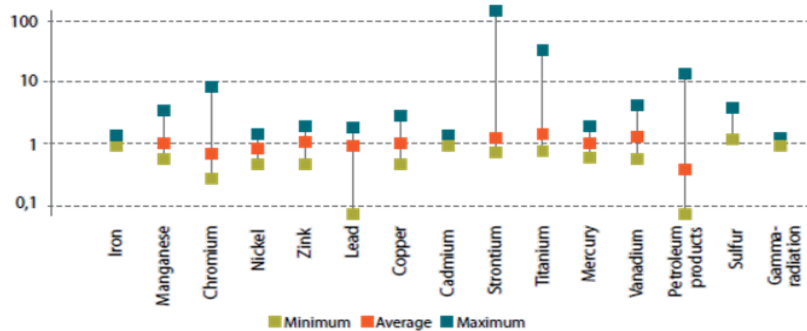
The April 1986 explosion and core meltdown of a reactor at the Chernobyl’ nuclear power plant in northern Ukraine had an enormous impact on the region’s environment. Radioactive materials from the accident seeped into the ground, contaminating farmland and the water supply. From 1992 to 2002 in Belarus, Russia and Ukraine, more

than 40003 cases of thyroid cancer were diagnosed among those who were children and adolescents (0–18 years) at the time of the accident, the age group 0–14 years being most affected (Fig.1) [4]. The long-term impact on human health and the environment is still being assessed.



**Fig. 1.** Incidence rate of thyroid cancer in children and adolescents exposed to Iodine-131 as a result of the Chernobyl accident

Armed conflicts affect lands and terrain, surface and ground waters, vegetation and wildlife in a number of ways. Hostilities significantly increase the risks of incidents at industrial and infrastructure facilities. Especially hazardous for the environment are conflicts that take place in industrialized regions possessing a large concentration of environmentally hazardous installations and facilities, as is the case in the Donetsk and Luhansk regions. Soil pollution in conflict-affected areas are shown in Fig. 2 [5].



**Fig. 2.** Relative difference of soil pollution in conflict-affected areas vs. the background level.

According to the Ministry of Health of Ukraine and the Ministry of Ecology and Natural Resources of Ukraine there are more than 3 million people living in more than 2000 settlements on radionuclide-contaminated territories only. Due to environmental deterioration, over the last 10 years medical incidence rate has increased by 25% on

average. According to World Health Organization data, 80% of environmentally induced diseases are severe and practically incurable illnesses. Information on environmental conditions such as air pollution, water contamination, epidemiological situation, radiological hazards level etc. has become vital.

Information as a special kind of resources and a factor of social development becomes a special type of product with all the properties of a product inherent to it. Ecological information (on the state of the environment, air pollution, water resources, epidemiological situations, the level of radiological danger, etc.) is especially valuable because it is vital for humans. Ecological information is necessary for all people, but its customers are those payable individuals and organizations that are at risk – money, reputation, health, life, etc. Moreover, the degree of risk and the possible price of information are directly dependent.

The existing environmental problems are relevant for humanity and raise the level of environmental awareness among the population requires the creation of new tools for organizing, storing, disseminating and updating environmental information resources [6]. However where and how to get such information promptly? Can the received information be trusted? These are the questions that the authors attempt to answer with their EcoSpotter project.

## **2 Analysis of research and existing solutions**

Analysis of accessible to public information resources and services that provide data on current environmental situation shows that obtaining reliable and up-to-date information is not an easy task. Following is an overview of some information resources that provide environmental monitoring data.

Environmental Interactive Maps [7] offers a list of interactive environmental maps of Europe. Water and soil pollution are represented best. Indisputable advantage of this resource is the variety of information. However, user-specified search for environmental data is complicated due to necessity to separate different forms of data representation.

Wireless Environmental Monitoring Systems (EMS) [8] provides data on the most reliable, consistent and accurate wireless environmental monitoring and control solutions by Hanwell Solutions Ltd. The Hanwell EMS software takes environmental monitoring data display to another level. The top-level displays a general overview of site sensor activity, with subsequent levels enabling customizable data groups for individual user requirements. Full data collection with interactive graphs, tables and plan views enable users to slice historical environmental data in multiple ways for more advanced analysis.

The Baltic Sea Region GIS, Maps and Statistical Database [9] is a result of the Baltic Drainage Basin Project, a multi-disciplinary research project under the EU. The datasets and maps have been combined into one interactive on-line map service. Database has become the most popular and pertinent environmental information resource about the transboundary Baltic Sea Region.

Lakes Environmental Company [10] offers a wide range of environmental software products. The Company provides a wide variety of services in the areas of air dispersion modeling, human health and ecological risk assessment, emissions inventory, compliance, as well as emergency release.

Climate Interactive Company [11] creates simulation models, interactive tools and programs for environmental and sustainability planning and education in such areas: climate change, energy, sustainability, environment, and disaster risk reduction.

Environmental Performance Index (EPI) [12] scores 180 countries on 24 performance indicators across ten issue categories covering environmental health and ecosystem vitality. The overall EPI rankings indicate which countries are doing best against the array of environmental pressures that every nation faces. Ukraine is on the 109th place (out of 180) in the 2018 EPI Country Rank.

Main Center of the Special Monitoring website [13] manages data of seismic, radionuclide, electromagnetic, infrasound monitoring, monitoring of nuclear tests and space weather, on both global and local scale, providing the state central government structures, which are responsible for the national security and defense, as well as other interested ministries and departments with all the required information.

Analysis of existing information resources that provide data on environmental situation and parameters leads to the following conclusions:

- Existing information services do not possess adequate degree of interactivity: the data is provide either as static maps or interactive maps with complicated and not user-friendly interface and limited functionality;
- Existing information services do not possess ecological monitoring data search tools;
- Information services software requires lengthy and complicated installation and configuration process;
- Information resources are narrowly focused on certain territories and/or provided data type;
- Information resources provide no recommendations on lessening or negating environmental hazards impact on human health and ways to improve environmental security.

### **3 Consumers of environmental information**

Consumers of reliable and timely environmental information were identified in the process of researching the problem. Such categories of environmental information consumers were considered:

- Real estate market;
- Agricultural business;
- Tourist industry;
- Recreational business.

The real estate market is inseparable from environmental issues that are relevant to people who want to improve the quality of their life. For example, information of the

environmental impact assessment of housing and its location, analysis of the state of drinking water, harmful emissions that pollute the air in the place chosen by the buyer of real estate is an expensive item.

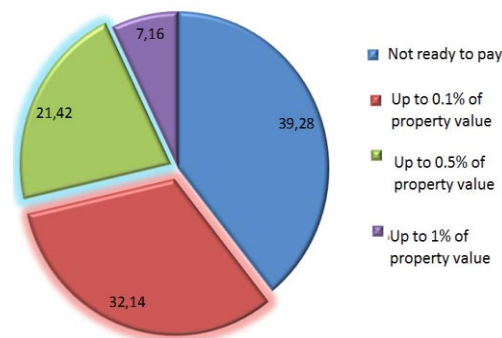
Problems of food security, environmental protection and conservation of natural resources are relevant for the agricultural sector. Agriculture is increasingly feeling the pressure of consumers, who need to increase not only the environmental safety of the products produced, but also the production itself in terms of its impact on the environment, and, consequently, the quality of life.

The implementation of the concept of sustainable tourism development provides for a close connection of natural and tourist resources. Eco-friendly regions attract tourists. There they can get a healthy rest and aesthetic impressions of communication with nature. Obtaining detailed and timely environmental information on the tourist route will help a potential tourist to make a decision regarding his resting place.

A person spends own physical and mental efforts through its work. Therefore, it should be able to maintain and correct the physiological state of the body during rest and recovery. To organize effective human recreation, it is necessary to take into account the ecological state of natural systems and the quality of the environment as a determining factor in recreational activities. Accounting, natural components (climate, water, balneological and mud reserves, phytotherapeutic factors, sea and beach resources) in the recreational process requires obtaining the necessary information about the environmental quality characteristics [2].

In conditions when the information becomes a commodity, you can get income and profit from its sale. Ecological information of a general nature should be available to users for free access. In order to allow market regulation of the demand for information, it should not be freely available. For efficiency, completeness, detail, exclusivity of data the consumer must pay.

A sociological survey conducted in Kiev on a sample of 1000 respondents showed that citizens are willing to pay for timely and reliable environmental data when property purchase (Fig. 3).



**Fig. 3.** The results of a sociological survey on the willingness of the population to pay for timely and reliable environmental data.

## 4 Problem statement

Within the context of environmental problems which society faces, development of ecological monitoring systems to provide timely, complete and reliable information on environmental state and civil protection from environmental hazards activities is a pressing challenge.

The goal of this work is to analyze the possibility of using the Microsoft Bing Maps cartographic service in a client-server application to provide quick and convenient access to data on the environmental situation in the region, presented in an interactive, intuitive form.

## 5 Functionalities of the web-resource

The web-resource has been developed to achieve this goal. The web-resource provides the necessary information on the environment in the user's locations. It forms recommendations on environmental protection and reducing the consequences of the harmful effects of environmental pollution on humans.

The developed software system implements such business processes.

- Collection of primary data by measuring devices of environmental quality such as gas analyzers, smoke meters, sound level meters, dosimeters and other devices, including those based at terrestrial means of obtaining environmental information;
- Data transmission using GSM-channels, radio channels or the Internet;
- Storing environmental data in a database: attributive (directories, objects of observation, measurements of environmental parameters), cartographic (terrain maps, thematic maps — radiological, chemical, and other types of pollution);
- Statistical data processing for the purpose of modeling and forecasting environmental situations;
- Expert analysis and expert assessment of environmental hazards, the choice of the best solution among the existing ones, forecasting the development of the process;
- Statistical analysis of environmental impact assessment; development of recommendations for management decisions-making in emergency situations;
- Visual display of environmental data (maps, graphs, charts);
- Reporting on the results of modeling, prediction of environmental situations, expert assessment, and preparation of advisory recommendations for minimizing harmful effects on humans.

The user can go to the web resource and chooses regions interested for him. The user receives information on the environmental situation in the area, indicating the corresponding label on the map. He can view video images, read general recommendations on reducing the impact of negative factors, obtain statistics on changes in pollution indicators, and move to a forum for discussions on the environmental issues.

The application loads polygons, data on the pollution of the area and displays them on an electronic map to view the parameters of environmental pollution. If a specific section on an electronic map is selected, the application calculates the polygon on which

the selection was made, requests specific values for the section from the database, and displays them to the user (Fig. 4).

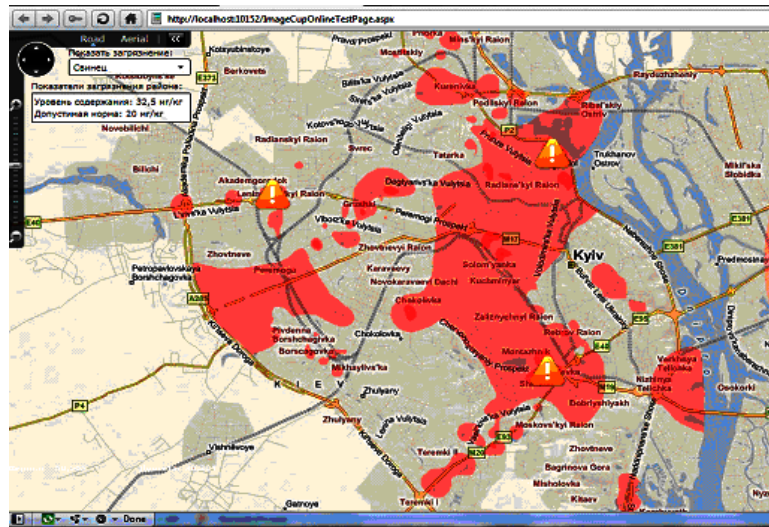


Fig. 4. An example of the EcoSpotter e-map of Ukraine's lead pollution.

The mobile version of the project is intended for user registration of environmental data at the location of their measurement. The user does not need to record the coordinates of each measurement; all that is needed is to send data to the server by mobile phone from the place of their measurement. Data processing, expert assessment, and issuing recommendations to the user regarding environmental hazards are performed according to the base scenario of the EcoSpotter system

## 6 Interactive Maps with Silverlight and Bing Maps

### 6.1 Bing Maps geometrical object

Bing Maps offers access to rich map imagery and data as well as robust search, location, and routing services. Silverlight based Bing Maps allows to choose the map view: a two-dimensional road map, a satellite view and a bird's eye view (axonometric). There is also an automatic mode that switches the views when you change the scale: initially a simple map is displayed, then the surface of the earth begins to turn and a three-dimensional view appears. Laser scanning used to form three-dimensional images of objects [14].

Bing Maps can assign multimedia objects, such as video, images, photos, tags, to specific regions and coordinates on a map. The EcoSpotter project implemented the ability to link a graphic object, which is represented as a region of a locality on an electronic map, with a semantic object – a representation of the subject area in terms of an ecological system. Each area of pollution on the map has relevant image, which



characterizes the type and level of danger, for example, radiation. The addition video content, multimedia objects and comments allows creating an integral system for displaying environmental information.

Working with a map is based on a polygon system, i.e. geometric shapes mapped and used to display polluted regions. The Bing Maps Silverlight SDK component allows you to apply such objects to a map on-line, which makes it possible to edit regions quickly. Each region is characterized by a danger level, which is visualized on the map in a certain color. The region is defined as a convex polygon. Polygons are stored in a database as a set of segments, each of which is defined by the geographical coordinates of its beginning and end. Regional information is also stored: pollution degree, hazard level, and other environmental parameters.

## 6.2 The problem of determining the user's positioning

User requests for environmental data are processed by selecting specific regions. To do this, it is necessary to determine a point on the map by its coordinates. This point on the electronic map will correspond to a specific location. The task is to determine the belonging of a particular point on the map to a specific region displayed by a convex polygon. To solve this problem, two algorithms were considered.

The first algorithm is based on splitting a convex polygon that represents a region of locality into triangles and verifying that a user-defined point belongs to triangles.

To determine whether a point is a convex polygon, its vertices are sequentially numbered from 1 to  $n$ . Line segments to all other vertices of the polygon connect the vertex 1. As a result  $n-2$  triangles with number of vertices  $\{1, n; 3 \leq i \leq n\}$  are formed. Verification of the belonging a given point to at least one of these triangles is carried out. Splitting a polygon into triangles and checking the belonging of a given point to triangles is performed for vertices with subsequent numbers until one of the conditions is satisfied:

- a splitting convex polygon into triangles, in which the point does not belong to any of the triangles, and, consequently, the point does not belong to the selected polygon;
- all vertices of the polygon are scanned, and the condition of the point's belonging to the triangle is checked for each vertex, therefore, the point belongs to the selected polygon;

The second algorithm is based on the idea of counting the number of intersections of a ray emanating from a given point in the direction of the horizontal axis with the sides of a polygon. If the number of such intersections is even, the point does not belong to the polygon.

As the experiments showed, the speed of the second algorithm is 10 times higher with the number of segments forming the boundary of the polygon, more than 20 thousand. Therefore, to solve this problem in this project, in order to increase efficiency, the most recent algorithm was used.

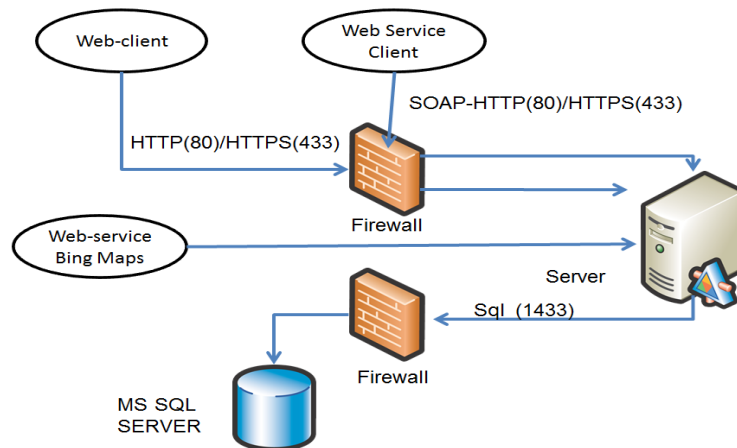
## 7 The EcoSpotter system architecture

The EcoSpotter system has three principal layers. Presentation logic is about how to handle the interaction between the user and the software. The primary responsibilities of the presentation layer are to display information to the user and to interpret commands from the user into actions upon the domain and data source. The presentation layer is implemented as a web client [15].

Data source logic is transaction monitors, other applications, messaging systems, and so forth. For EcoSpotter system the biggest piece of data source logic is a database that is primarily responsible for storing persistent data.

The domain logic, also referred to as business logic is the work that EcoSpotter system needs to do. It involves calculations based on inputs and stored data, validation of any data that comes in from the presentation logic, and figuring out exactly what data source logic to dispatch, depending on commands received from the presentation logic.

The EcoSpotter software system includes the following components (Fig. 5):



**Fig. 5.** The EcoSpotter system architecture.

- Database server running MS SQL Server. The database contains data on environmental pollution parameters (region name, type of pollution, degree of pollution, environmental pollution);
- XML Web Service Microsoft Bing Maps. The service provides management of the coordinates of the points on the map and determinates the latitude and longitude of the marked point of the map;
- Microsoft Bing Maps Silverlight SDK. Silverlight is a user interface component that allows to put on a map the polygons and geometric shapes, change its appearance, and process coordinates to calculate the location of objects [16];
- ASP.NET application for creating a Web interface and displaying the Silverlight component;

- Microsoft IIS Web Server is the environment for the functioning of the Web application;
- Expert System is a component that develops and evaluates the possible solution alternatives. The decision is limited to choosing one of the proposed alternatives. The component of the expert system uses the Bayesian system of logical output. It is intended for the user consultation with the expert in the field of environmental safety in order to determine the probabilities of possible events and uses for this the assessment of the probability of environmental hazards [17].

## 8 Conclusion

Authors have analyzed current state of population environmental awareness and protection from hazardous environmental factors impact. The authors consider the feasibility of creating publicly available information resources and services that provide data about an ecological situation and degree of ecological contamination of concrete region. The use of the Microsoft Bing Maps service opens up a wide range of possibilities for creating applications. The described application collects data on the ecological state of the environment in a specific region in the amount necessary for its analysis and decision-making on environmental issues. The environmental database uses mobile systems, instrumentation, environmental sensors and devices. The program provides control of the credibility and relevance of the data through the involvement of experts in the field of environmental protection.

The reviewed elements of algorithmic tools and software were implemented in one of real estate agencies in Kyiv (Ukraine).

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