ISSN: 0975-766X
CODEN: IJPTFI
*Available Online through* *Research Article*
**www.ijptonline.com**

# MONITORING OF ILLEGAL PLACEMENT OF SOLID WASTE WITH THE USE OF SPACE TECHNOLOGY

**Rafail Mustafin[a1], Irina Malganova [b]**
[a, b] Kazan federal university, Kremlevskaya ,6/20, Kazan 420111, Russia.
*Email: Rafail.Mustafin@tatar.ru*

*Received on 14-08-2016* *Accepted on 20-09-2016*

**Abstract**

This article is devoted to development and use of the space and geoinformational technologies allowing the state and municipal operating controls to carry out continuous monitoring of city and suburban territories regarding identification of unauthorized garbage dumps, to carry out control of their elimination. The purpose of the conducted research is definition of optimum ways with minimum expenses of labor and life capabilities to carry out searching of unauthorized garbage dumps and to provide monitoring for clear and rather in settlements. Object of a research is the modern territory of Kazan and its vicinities, with a total area more than 600 sq.km, numbering inhabitants more than 1,2 million human. In work traditional geographical methods were used: cartographical, based on methodological bases of thematic and complex mapping, on achievements in the field of geoinformational technologies, comparative and descriptive, a method of the space analysis, statistical. As a result of the conducted research the technique of probability assessment of placement of municipal solid waste with use of space and geoinformational technologies which will allow to make well-timed administrative decisions is developed and introduction of expressly developed hardware and software system on monitoring and holding the actions directed to elimination of unauthorized locations of municipal solid waste is offered.

**Keywords:** space technology, geographic information system, geospatial data, geological interpretation, space images, solid waste

## Introduction

Kazan is located on the left-hand bank of the river of Volga, at river falling into it Cauldrons, in 820 km to the East from Moscow. Thanks to a favorable geographical arrangement, Kazan long since was a reseller between the East and the West. Kazan – one of the largest industrial, financial, shopping and tourist centers of Russia leading on investments into fixed capital and construction the city of the Volga region. In 2013 the bulk product of the city made

486 billion rubles, the volume of the shipped production made 254 billion rubles, retail trade turnover – 410 billion rubles. In Kazan was comprehensive programs "Green record" and "the Blossoming Kazan" are started and realized. Annually about 5 million flowers land. Within the city project "Green Record" 530 thousand sq.m of new lawns are laid, 78 km of automatic watering system are laid, the area of flower registration of the city is doubled. New life was found by one of city sights – picturesque Bulak Canal. Now on Bulaka the gushing complex 1,4 km long is mounted [1]. In spite of the fact that Kazan is one of the most high-growth cities of Russia, in the city there is a set of socially important problems, one of which is the ecology. The main environmental problems are: pollution of the atmosphere, unsuccessful quality of waters of Volga, Cauldrons and other reservoirs within the city, poor gardening of the city, and also utilization of garbage. In Kazan two grounds on placement of Samosyrovo municipal solid waste and down the street Chemical work, at the same time the samosyrovsky ground already exhausted the opportunities and demands recultivation. Also 2 waste sorting complexes work with total capacity of 250 thousand tons per year.

In 2014 construction of three treatment facilities on networks of the stormwater drainage system is complete. And to reduce concentration of harmful substances in air, all public transport in Kazan is transferred to the Euro-3 standards and Euro 4. On the Volga water intake electrolysis installation on production of hyposodium chloridum is opened up. It allowed to refuse water treatment by means of chlorine, unsafe for health, and to pass to the European standards of disinfecting of tap water [2]. Assessment of competitiveness of administrative and territorial units became one of the most important problems of development of city and suburban farms in the modern conditions. It is especially important in connection with deepening of process of globalization and the begun transition of society to a post-industrial stage of development [3]. Assessment of level of social and economic development of the cities of Russia is the important tool for definition of quality and effectiveness of areas of management [4].

In the conditions of post-industrial development of the cities the role of their positioning and competitiveness considerably increased in fight for investments, innovations, high technologies [5, 6].

Considering importance of ecology in development of any modern city, topical issue is introduction of the modern geoinformational technologies in this field of activity.

GIS is used for problem solving of the social and economic analysis of regional and city systems, and also there is a prospect of application of GIS for realization of trial functions of management city economy [7].

Districts of Kazan and its vicinity significantly differ on the majority of socio-economic indexes and development of the corresponding infrastructure. At the same time implementation of city programs which have to consider the

prospects of development of administrative and territorial units taking into account their specifics, form a basis for development of target actions, support of the most perspective projects has special value. At the territorial level administrations of municipalities [8, 9] are engaged in development and realization of investment policy.

One of the most perspective and significant mechanisms of increase in effectiveness in municipal economy is use of space technologies, including use of data of the remote sensing of Earth (RSE).

Now there is urgent a question of development of geographic information systems on environmental monitoring, intended for complex informational and analytical providing reversal processes with waste products and consumption, including:

- operating control of places of unauthorized placement of waste products and consumption (further in the text – NRO);
- performing calculations of the area and volumes of NRO;
- identifications and punishments of violators;
- schedulings of the course of conducting checks on NRO;
- maintaining archives of places of NRO
- placements of results of the analysis on the card in points of selections in the form of charts
- creation of a mathematical surface of value distribution of an index in the explored territory by an interpolation method, and receiving an orthogonal projection of the calculated surface on the card in the form of isolines [10], etc.

**2. Materials and Methods**

Within creation of System different types of activity which are implemented within the functional subsystems are automated. The system includes the following types of the automated activity: identification of places and performing calculation of the area and volumes of NRO; definition of the owner of NRO and its punishment, control of elimination of NRO; preventive measures for prevention of NRO; conducting document flow; maintaining archives of places of NRO without restriction of limitation periods; the publication of an open part of information on the geoportal. The geospace database with a possibility of storage of geometrical objects is developed. On the geoportal the structure is designed and information on the production platforms, garage and garden cooperatives is injected. Key sites of unauthorized placement of a wastage in the territory of the city are defined. On the basis of the available geospace information the probability model of places of unauthorized placement of a wastage taking into account

federal highways, ravines, country and garage cooperatives, the enterprises, afforestations is created. Today at increase in volumes of the data obtained from satellites, the data of remote sensing of Earth (DRSE) become one of the main sources of information on state of environment. Owing to this fact the task of studying and assessment of opportunities of identification of places of the unauthorized placement of a wastage (UPW) on the basis of DDZZ of high spatial resolution for the purpose of development of a subsystem of definition of places of NRO with use of DDZZ for the Intelligence system of environmental monitoring of components of a surrounding medium was set. During the processing and interpretation of materials of remote sensing except materials of space-shooting sharing of various cartographic materials, padding thematic space information on the studied territory is necessary. It is necessary both for more precise binding of satellite images, and for their interpretation, in particular definition direct or indirect the deciphering signs - properties of the allocated objects (in our case NRO) finding immediate display in pictures. For submission of space data in GPBD the vector model of data within which objects are represented by model geometrical objects of three types was used: points, lines, grounds. As grounds are presented: lakes, reservoirs, part of the rivers, islands, forests and other vegetation, settlements, quarter, structures, part of elements of a relief (ravines), borders of garage and garden cooperatives. As the linear objects are presented: rivers, roads, glades, relief isolines, relief elements (ravines). As dot objects are presented: road constructions (railway platform). Information provided in GPBD is organized in layers; model objects are grouped in layers in a thematic sign and as objects.

**Served as informational filling of GPBD:**

the vector cartographical layers received from the executive committee Kazan, corresponding on space specification to scale 1:2000, water objects, roads, building, vegetation, borders of garage and garden cooperatives received according to inventory of lands (fig. 1);2) the vector cartographical layers of GIS "Environmental management" which are corresponding to scale 1:100000, acting as an all-geographical basis and bearing information on objects in the territory: water subjects, roads, settlements, woods, elements of a relief (fig. 2).

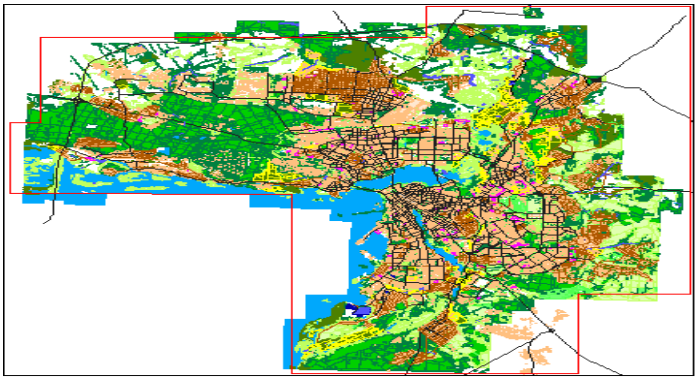

**Fig. 1. Vector cartographical layers of Kazan.**

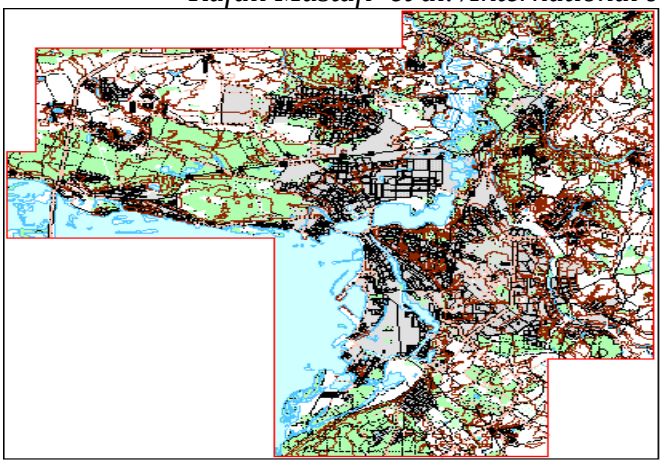

**Fig. 2. Vector cartographical layers of GIS "Environmental management".**

During interpretation of data of remote sensing is attracted also other additional spatial information on the studied territory, the complex analysis which allows to optimize process of allocation of objects was carried out, to aim efforts to the analysis of certain sites of satellite images depending on a solvable task. Division into districts of the territory of Kazan on the basis of the constructed probabilistic model of places of NRO with use of the available information from GPBD was for this purpose carried out.

Creation of probabilistic model and the subsequent division into districts is based on complex assessment of influence of various factors on probability of NRO.

Let's consider any point of the territory as the possible place of unauthorized placement of waste ("receiver") and we will estimate its potential as possible "receiver" of waste (place of unauthorized placement of waste). Let's make assumptions that "appeal" of the place to unauthorized placement of waste (probability) depends on its proximity to, so-called, to objects receivers, i.e. objects of certain B1, B2 types, …, Bm in the neighborhood of which usually and unauthorized dumps settle down (for example, to ravines, wood edges, roads and so forth). Then the potential of a point x as "receiver" of NRO it is possible to estimate as follows:

$$P(x;B)=\sum_{i=1}^{m} w_i P_{Bi}(x),$$

where

$$P_{Bi}(x)=\begin{cases} 1, npu\ r_{Bi} < r_{1Bi} \\ 1-\dfrac{r_{Bi}-r_{1Bi}}{r_{2Bi}-r_{1Bi}}, npu\ r_{1Bi} < r_{Bi} < r_{2Bi} \\ 0, npu\ r_{Bi} > r_{2Bi} \end{cases},$$

rBi – the shortest distance from a point x to a Bi, r1Bi object – distance from a Bi object on which its influence can be considered constant and maximum, r2Bi – distance from a Bi object since which influence of an object can be neglected wi – the weight of Bi objects as receiver of waste. Within probabilistic model of weight wi are considered as aprioristic probabilities (their sum is equal to unit) therefore represents spatial distribution of probability of a possibility of placement of NRO.

The second element of model are so-called objects - "sources", i.e. objects of certain A1, A2 types, …, An, which can be considered "sources" of waste for places of NRO (for example, residential districts, garden societies, highways, railway platforms, etc.). Let's estimate the potential of any point x as source of waste:

$$P(x;A)=\sum_{i=1}^{n} v_i P_{Ai}(x),$$

where

$$P_{Ai}(x)=\begin{cases} 1, npu\ r_{Ai} < r_{1Ai} \\ 1-\dfrac{r_{Ai}-r_{1Ai}}{r_{2Ai}-r_{1Ai}}, npu\ r_{1Ai} < r_{Ai} < r_{2Ai}, \\ 0, npu\ r_{Ai} > r_{2Ai} \end{cases}$$

rAi – the shortest distance from a point x to an Ai, r1Ai object – distance from an Ai object source on which influence of a source can be considered constant and maximum, r2Ai – distance from an object – a source like Ai since which influence of a source can be neglected vi – the weight (relative power of objects sources) of the Ai type. Within probabilistic model of weight vi are considered as aprioristic probabilities (their sum is equal to unit) therefore represents spatial distribution of probability of education and possible movement of waste.

**3. Results**

As a result of the carried-out work the probabilistic model in two options was constructed: 1) according to more detailed data of scale 1:2000 with attraction of missing information on relief elements from scale 1:100000; 2) according to scale 1:100000 with attraction of missing information on building, garden and garage sites from scale 1:2000.

For representation of results of spatial division into districts of the territory on the basis of model of probability of places of NRO the raster model of submission of spatial data was used (the grid cell size 5×5 m).

Previously for each type of the objects used in model as receivers or sources remote transformations (raster layers of distances to objects of this type) on grids with the same parameters were constructed, and further, according to the

formulas given above, values of probability of NRO in each cell of a grid were received. The received results of spatial distribution of probability "are disguised" by borders of the project territory, reservoirs, forests and buildings. For calculations means of an ArcGrid package of the ArcGis system and means of system of the automated data processing of remote sensing of ScanEx IMAGE Processor were used.

The constructed zoning maps of the project territory on the basis of model of spatial distribution of probability of places of NRO, one of fragments is given in the figure 3. The corresponding raster cartographical layers are included in structure of GPBD of a subsystem and are available to the joint analysis with DDZZ for the purpose of definition of places of NRO.

It is obvious that quality of results is influenced significantly by completeness and detail of initial information. At this stage of works for assessment of a number of factors, for example, about relief forms, small-scale information was attracted (1:100000); completeness of the geospatial information which is available in GPBD also leaves much to be desired, both on coverage of the territory, and on subject. After providing fuller and detailed vector information on the project territory the model can be specified.

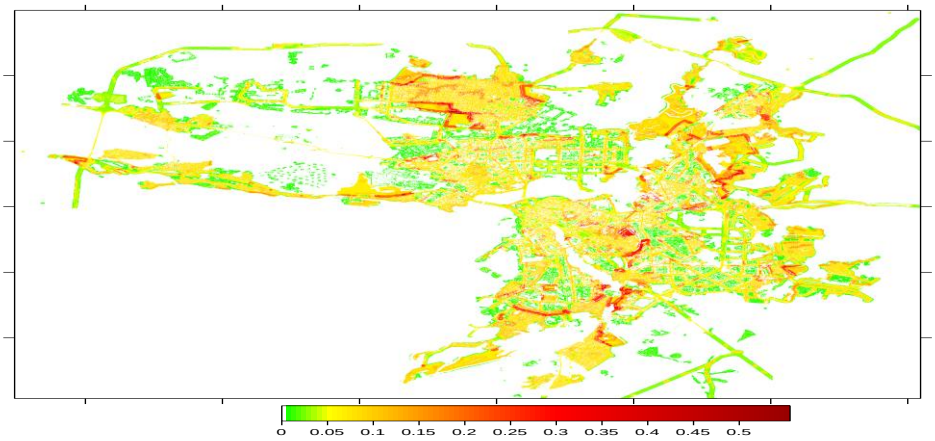


**Fig. 3. Zoning map of the project territory.**

## 4. Conclusions

One of the main objectives of a subsystem is definition of places of NRO with use of previously processed DDZZ. The initial pictures received from the QuickBird satellite represent values of spectral brightness in 4 spectral channels (B, G, R, NIR) with the spatial resolution of 2,4 meters, and also values of the integrated spectral brightness (PAN) with the spatial resolution of 0,6 meters. Preliminary processing of DDZZ includes performance of the following operations: photometric correction, geometrical correction, creation of mosaics on the set territories, creation of the synthesized images, obtaining the synthesized color image of high resolution by the procedure of merge of the panchromatic image (with high spatial resolution) and the polyzonal image (with low spatial resolution).

The provided pictures were subjected to procedures of photometric correction and geometrical correction which main objective to provide with the maximum accuracy transition from internal system of coordinates of a picture to the chosen cartographical system of coordinates. Transformation of pictures in a cartographical projection is carried out as on high-precision measurements of orbital parameters (the angles of orientation of the satellite and the camera, camera parameters - time of scanning of one line, focal length lens distortion parameters), and on reference points with use of cartographic materials, measurements in systems of geopositioning or with attraction of earlier transformed pictures. The received geobinding often is insufficiently exact. Using information on coordinates of objects from large-scale cartographic materials it is possible to execute geometrical correction with higher precision. In our case geoinformation of a layer of water objects of scale 1:2000 of GPBD was attracted to specification of a geometrical binding and implementation of correction (polynomial transformation).

On the basis of DDZZ and the created probabilistic model of places of NRO the mechanism of visual decryption of various types of places of warehousing of waste is developed. Methods of extraction of information from DDZZ at all their variety come down to two basic:

- visual, during the work with images on the monitor screen;
- automated, carried out within systems (packages) of the automated data processing of remote sensing supporting various methods of spectral classification of images.

In the methodical relation a basis of interpretation (decryption) of pictures is the combination of cameral and field works. Field decryption of pictures is made directly on the area, by comparison of objects of the area to their images in pictures. Cameral decryption is carried out in cameral conditions by recognition of objects on their synthesized image with use of various cartographic and reference materials, and also decryption standards. The combination of field and cameral methods of decryption is most effective and reliable. In this case in cameral conditions the greatest possible quantity of objects is decoded, in field conditions decryption of not represented objects is made and a set of missing metric and other characteristics is supplemented.

**Discussion**

An important role in development of the cities is played by use of innovative technologies. A task of city services is the analysis of impact on the environment. Restrictions can arise as for reasons of ecology and preservation of the adjacent especially protected natural territories, and because of danger of pollution of the ground and surface water feeding sources of water supply of the city or settlement. It is possible to define places of such restrictions by the

means of the spatial analysis mentioned above, and it is necessary to control their execution by means of space and geoinformation technologies. Besides, for increase in efficiency of maintaining municipal economy by local government bodies creation of a specialized web resource on which to provide a possibility of the centralized order and purchase of satellite images, preview and their use in local geographic information systems is expedient. It is necessary to create system of the authorized access to the specified web resource for residents who will be able to watch in real time an ecological situation of the city and to control actions of local government bodies.

**Acknowledgments**

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

**References**

1. The official portal of the City hall of Kazan on the Internet of http://www.kzn.ru
2. The official site of the Ministry of Ecology and Natural Resources of the Republic of Tatarstan on the Internet of http://mepr.tatarstan.ru
3. Gallyamova, D.K., Toumashev, A.R., Malaev, V.V. Influence of globalization on development of the Russian economy. Mediterranean Journal of Social Sciences, Vol. 5, Issue 18 SPEC. ISSUE, 2014, Pages 133-138
4. Glebova, I.S., Rodnyansky, D.V. Investment potential of subjects of the Volga Federal District of the Russian Federation as a factor of the territorial development. Mediterranean Journal of Social Sciences, vol 6, Issue 1S3, 2015, Pages 322-326
5. Enright M.I. The Geographical Scope of Competitive Advantage // Stuck in the Region? Changing scales for regionalidentity. Utrecht, 1993.P. 87-102; Porter M.E. The Competitive Advantage of Nations // Harvard Buisness Review. 1990. March – April. P. 73-93. 9
6. Bagautdinova, N.G.a, Galeeva, G.M., Fazlieva, E.P., Arzhantseva, N.V. Investment attractiveness of the region as the factor in the formation of competitive advantages. Mediterranean Journal of Social Sciences. Vol 5, Issue 28, 2014, Pages 9-13
7. Panasyuk, M.V., Pudovik, E.M. The application of geoinformation systems for the purposes of economical-statistical analysis. Mediterranean Journal of Social Sciences, Vol. 5, Issue 18 SPEC. ISSUE, 2014, Pages 145-148

8. Mustafin R. A., Bulatova G. N. Integrated assessment of investment appeal of areas and city districts of the Republic of Tatarstan with use of geoinformation technologies, the Bulletin of the Udmurt university, 2014, No. 6-2.
9. Mustafin R. A. Formation of mechanisms of increase in investment appeal of regions on the basis of use of modern geoinformation technologies, the Abstract, 2014.
10. Geoinformation portal of http://www.gisa.ru/1002.html GIS-association.