High Resolution Space Images for Hazardous Waste Area Monitoring with Application of Remote Sensing and GIS

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Abstract

One of the main cases of the desertification impact is the negative contribution of human activities that worsen environment. There are historical facts of inability and excessive activities which destroyed the civilizations. The basic difference is only in the tempo and scales of civilization collapse. Human pressure was accumulated within the centuries and millennia due to the extremely active economic activities. But today it covers only the decades. Presently the process of desertification has a global scale. There are huge factors of Earth aridization as an increase of the quantity of CO_2 and atmospheric dust and bloom. This process related not only to the arid areas. Obviously a comprehensive approach of development of territories, particularly arid areas is very important.

The use of the satellite information and technologies of remote sensing data processing can take a significant place for decision-makers for calculation and estimation of the environment impacts.

Key words : remote sensing, GIS, space images, image processing, area monitoring

Introduction

The traditional dumps cause infinite number of problems: rodents and birds, water body pollution, spontaneous combustion, waste air emission and etc. The so-called "sanitary" polygons first appeared in the fifties, the waste in these polygons as interspersed with soil.

The dump/polygon for the waste disposal is the complicated system. The study of this system has started recently. The point is that the substances meant for burial as well as the polygons appeared 20-30 years ago. And nobody supposes when they will decay. After scientists began research of the old polygons, they found out that 80% of the organic substance (vegetables, hot dogs and ecc.) had not decayed for the 15 years. Sometimes scientists could read the newspaper of the thirty years' prescription. All the latest polygons have no contact with the environment. But namely that condition hampers the waste decay process. So they represent the "delayed action bomb" .

The lack of oxygen causes the anaerobic fermentation of the waste. As a result the methane and carbon monoxide mixture are formed (so-called "dump gas"). In addition the toxic liquid is concentrated in the dump depths ("filtrate"). The "filtrate" shall not fall into the water bodies and bottom water.

The polygons requirements include requirements for area selection, construction, exploitation, and monitoring, mothballing and financial assurance (in case of distress and etc).

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The polygon area shall not be near airports, water bodies, swamps, tectonic break and seismic regions.

The goal of presented paper is to support decision−making of suitable area selection for waste burial in the investigated territory which was called Polygon (Fig.1.b).

Methodology

The subject of study is investigation of the arid territory taken as an example of the reserved area of saline lake.

Approbation stations are given on the Polygon (Fig.1.b) where conducts an analysis of soils and required studies are implemented by ground−based methods. In the conditions of remoteness and absence of population in these territories are enough time consuming and demand big financial contributions. These circumstances made necessary the use of satellite data for selection of suitable waste burial area for the toxic wastes with a minimum threat for environment in arid territories. For this purpose high−resolution satellite image IKONOS (1−4m) was used with application of space technology data processing and interpretation.

For this reason it was offered to use the approach which was based on application of remote sensing methods for data processing and development of integration of GIS technology. The concept of integration consists in detailed terrain map classification received as a result of high−resolution satellite image processing and using the GIS technologies due to the analysis and interpretation of space data with purpose of creation of digital thematic maps. This source of information can be a key instrument for further decision−making. So presented implementation will be carried out in two phases: satellite image processing and creation of digital maps of the ecological point of view.

In the first phase as a result of the preliminary analysis the methodology of image processing is developed for a specific target. The material consists of the following components:

1. Software maintenance. Two available software packages were undertaken: ENVI 3.2 − for satellite image processing and ArcView 3.2 for GIS development;
2. Remote sensing Data Sources. For these purposes were used space images IKONOS related to 2006 year with 1 − 4m resolution and the specialized technology of processing has been developed accordingly;
3. Other sources of data were sketch maps, schemas of the basic points of ground−based measurements and waste burial Polygon and description of flora and fauna of the area.

Data processing methodology is divided into two basic stages: preliminary (preprocessing) processing, basic thematic processing.

Preliminary processing as a main stage

Combined processing of space images and other informational sources start with location inspection of the Polygon where it is necessary to select appropriate place for waste burial. With this objective using the GIS tools satellite image and the Polygon layout is led to a local topographic map projection (Fig.1.c).

The results of numbering and binding of images, the topographic maps and schemes of Polygon location (Fig.2) allows to be guided to precise binding and satellite information interpretation for further data processing. For presentation of further processing results, whole territory has been divided into squares according to a map nomenclature sheet. In the next step all of approbation stations and processing results are presented within the scale of each square.

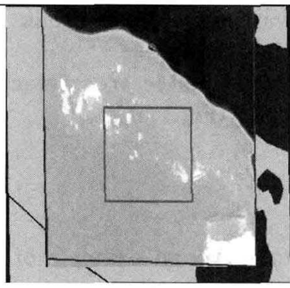

Fig. 1. a. General position Polygon in the arid zone

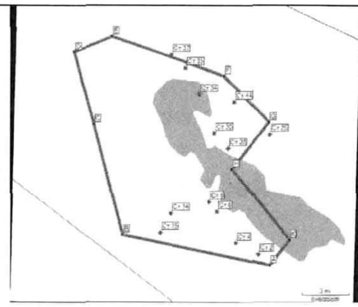

Fig. 1. b. Relative location of approbation stations

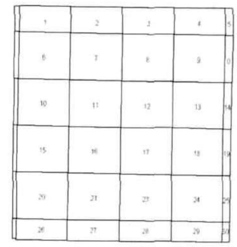

Fig. 1. c. Sketch map squarenumbering

Aprobation station location regarding frames of polygon and image.

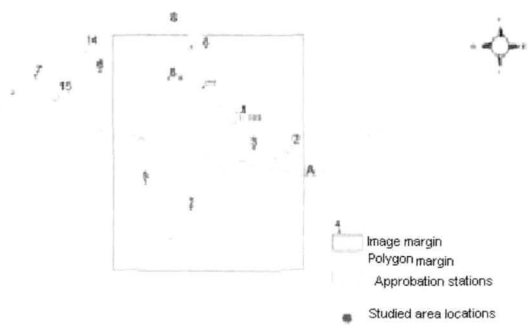

Fig. 2. Relative location of Polygon and satellite image

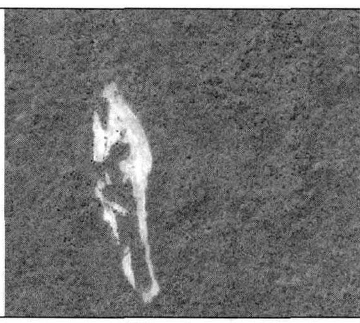

Fig. 4.a.

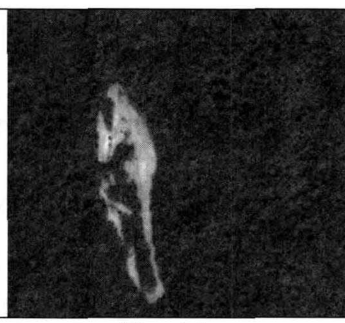

Fig. 4.b.

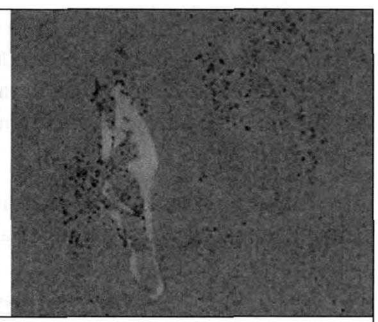

Fig. 4.c.

Before beginning image objects recognition, the preliminary processing was implemented for further image visual analysis developments. In this stage the ENVI 3.2 software's database (group of transformation Filtrs–Texture) was used.

Figure 4.a. shows that combination of 3 canals (nir, grn, and red) makes possible to get the image in origin colors. At the Figure 4.b. the transformation allows to select of image texture, and at Figure 4.c. –transformation enables to select single objects, which was unclear at the previous images. Last transformation allows to get an etalon fragment– single bushes. In all images saline land is allotted clearly. Saline lands were chosen as the first object of recognition.

Classification results

At the first stage the visual analysis of the image, its further processing (Fig. 2a) and the analysis using the GIS technology (Fig.2.b) demonstrate that to construct waste burial Polygon is impossible in squares numbering 1, 2, 6, 7, 12, 8, 13, 18, 23, 24, 27 – 29. The territory in the mentioned squares is located in a zone of saline lake (shown by blue color) and lilac color marks territory with very heavy saline soils. Digital processing of images was carried out using the ENVI3.2 classification procedure by applying algorithm of unsupervised classification ISODATA.

It is observed of clear fragmentation in parts where soils are very salted – lilac color (except salines) and visually homogeneous yellow color zone (which was interpreted as hilly sand on the sketch map). This zone as well at the visual decoding is characterized by separate vegetative groups availability (can be interpreted as bushes).

Taking into account all above indicated issues construction of Polygon in the very salted zones is not recommended due to the process of salinity and degradation of soils (as the result of vicinity of saline lake). Saline land formation in the region of well is demonstrated on Figure 3.b (square №18). Saline land formation in the other zone is demonstrated on Fig.3.c (square №6).

As an output of the fist processing stage in the results of classification and image analysis were developed the preliminary legend of maps including the following objects: saline, water objects, the homogeneous vegetative associations, the salted lands, wells and the degraded grounds around wells, inshore sand, roads, soils (sand, hilly sand).

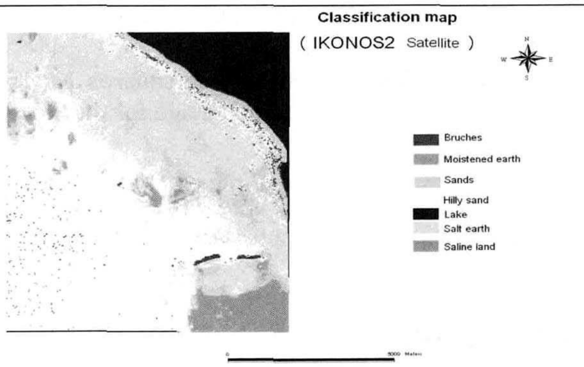

Fig. 2.a. İKONOS (ISODATA) Image classification results

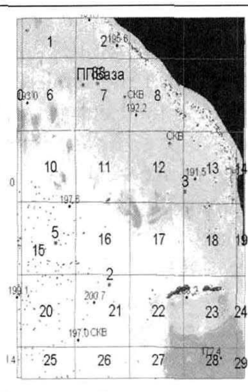

Fig. 2.b. Nomenclature squares overlaying on classification results

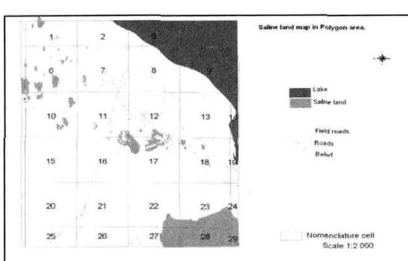

Fig.3.a. Map – Saline land recognition scheme per squares

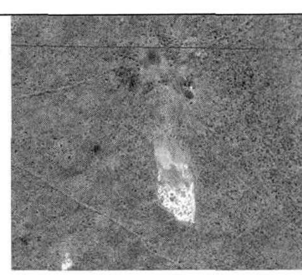

Fig.3.b. Saline land formation in the immediate region of well (square №18)

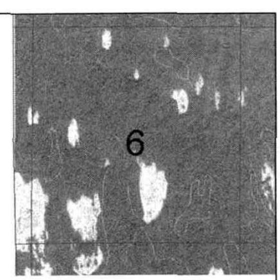

Fig.3.c. Per unit area №6 is 484272.6m2 saline land

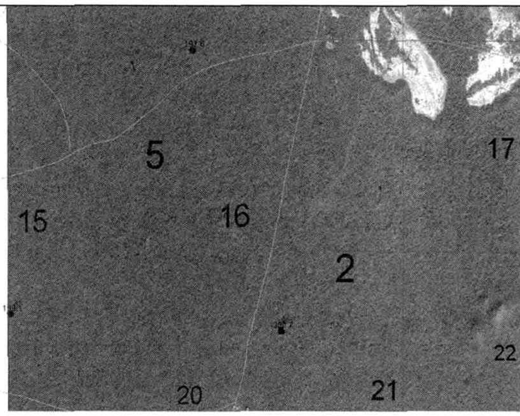

Fig.5.a

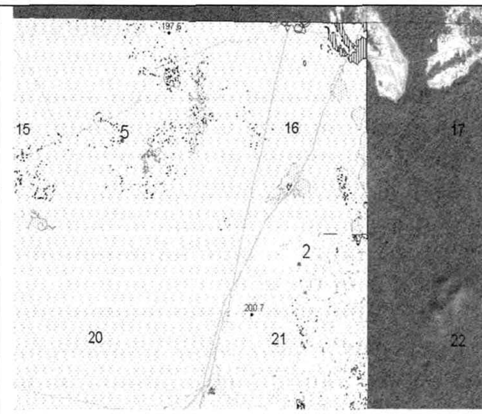

Fig.5.b

In the second phase within the scale of GIS an initial sketch map to be updated, corrected based on collected local material. And digital thematic maps of environment will be designed on the base of land use map. Creation of thematic vector layer using the GIS technology is the basic instrument of digital cartography. Comparison the vector layer from sketch maps with received as a result of digital satellite image processing allows to develop the geoecological analysis of local area and ecological maps.

Saline is precisely allocated in all images (initial and processed). If the Polygon's square in the satellite image occupies 6921 ha from them 577 ha (5777115.1m2) occupy saline. The territory on a square 6 (Fig.3.c) has the most tight allocation of saline. The square of all saline is equal 484272.6m2 or 48 ha.

Based on a result of the analysis Fig 5.a and Fig 5.b areas located on squares 15, 16, 20, 21 are the most suitable for Polygon construction. There are several advantage for this issue:

- a network of field roads;
- water sources around areas (wells and etc.);
- a homogeneous by structure of soil-vegetative characteristics;
- the lack of process of formation of saline as demonstrates visual and automatic decoding.

Conclusion

The polygons are the most common method for the waste destruction at the moment. Yet this method may cause the following problems:

- Quick overfilling of the existing polygons by reason of large volume and little density of the waste. The waste average density is equal to 200-220 kg/m3 before prior compression and only 450-500 kg/m3 after compression using garbage truck.

- The negative environment impacts are as follows: contamination of the bottom water with leachables, odor nuisance, waste air emission, spontaneous combustion of the polygons, uncontrolled formation of methane, waste mean appearance. And that is only a tip of the iceberg in ecologists opinion which causes alarm among local authorities.

- The lack of the polygons area at the convenient distance from the metropolises. The metropolises displace the polygons. And that factor coupled with high ground prices causes the high shipment cost.

- Impossibility of Polygon removal. In spite of the high technologies our community is always in need of the polygons for destruction of the untransformed fractions i.e. aches, tires, scrap metal, construction waste.

In this case Remote Sensing data processing with its tools offers an effective means for waste burial area selection and polygon construction.

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