

# ADVANCED R&D AND TECHNOLOGIES

## THE NAS OF UKRAINE



**ENVIRONMENT  
AND  
NATURE  
PROTECTION**

# ADVANCED R&D AND TECHNOLOGIES

THE NAS OF UKRAINE

## **SPECIAL ISSUES**

### **ENVIRONMENT AND NATURE PROTECTION**

FOOD INDUSTRY

FUEL, LUBRICANTS, AND TECHNOLOGIES

INDUSTRIAL AGRICULTURE  
AND LANDSCAPE GARDENING

INFORMATION AND SENSOR SYSTEMS  
AND DEVICES

INFORMATION TECHNOLOGY

MACHINE-BUILDING AND  
INSTRUMENT ENGINEERING

MEDICAL PRODUCTS  
AND MEDICAL DEVICE ENGINEERING

POWER ENGINEERING AND ENERGY EFFICIENCY

TECHNOLOGIES AND EQUIPMENT  
FOR EXPLORING, ESTIMATING,  
AND EXTRACTING MINERAL RESOURCES

TECHNOLOGIES FOR CONSTRUCTION  
AND FUNCTIONAL MATERIALS

## BIOSENSORS FOR DETECTION OF ALKALOIDS AND OTHER NATURAL TOXINS



Appearance of biosensor system

### Advantages

There are no commercial counterparts. The proposed system does not require presampling; is notable for a short time of analysis (rapid analysis), low labor intensity and cost of analysis, a high sensitivity and selectivity of determination; can be used for real-time field measurements

### IPR Protection

IPR3

### Areas of Application

The system is designed for detection of alkaloids and other natural toxins in agriculture and for monitoring of toxic substances

### Specification

Bioselective element	Butyryl cholinesterase	Acetyl cholinesterase
Analyte	Glyco-alkaloids	Aflatoxins
Detection limit, $\mu\text{g/ml}$	0.2	0.1
Linear range of detection, $\mu\text{g/ml}$	0.4–100	0.2–40
Operational stability, hours	12	12
Storage stability, months	2	2
Time of analysis, min	20	20
Measurement error, %	$\leq 10$	$\leq 10$

### Stage of Development.

#### Suggestions for Commercialization

IRL6, TRL5

The system is manufactured upon request. Seeking partners for commercial production

### Contact Information

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## BOTTOM WATERS DEGASSING BATHOMETER



### Areas of Application

The device is used for sampling bottom water in the seas, rivers, and closed water reservoirs, as well as for sealing and degassing in order to study water-soluble gases and to carry out environmental studies

### Specification

Sampling at a depth, m	≤2000
Volume of water sample, l	≤10
Volume of degassed sample, cm <sup>3</sup>	5–250
Material	Stainless steel
Weight without samples, kg	64
External dimensions, m	1.36 × 0.4

### Advantages

Improved reliability of bottom water and dissolved gases samples and possibility of sampling in deep waters; improved reliability of sealing valves

### Stage of Development.

#### Suggestions for Commercialization

IRL5, TRL6

Upon request, the device is manufactured, supplied, and maintained during the warranty period; staff training is provided



### IPR Protection

IPR3

### Contact Information

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## CATALYST FOR PURIFICATION OF INTERNAL COMBUSTION ENGINE EMISSIONS FROM CO, NITROGEN OXIDES, AND ORGANIC COMPOUNDS

### Areas of Application

The catalyst is to be used for purification of exhaust gases produced by steam generators and vehicles from CO, NO<sub>x</sub>, and organic compounds

### Specification

Honeycomb-structured blocks of given shape with longitudinal channels to ensure a low gas-dynamic resistance.

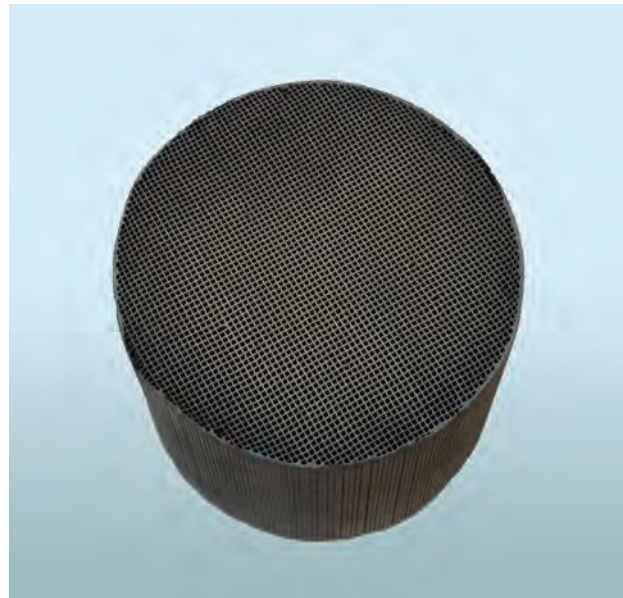
Purification from:

CO – 95–98% (95% conversion is achieved at 170 °C);

NO<sub>x</sub> – 98–99% (98% conversion is achieved at 220 °C);

Organic compounds – 90–98% (90% conversion is achieved at 300 °C)

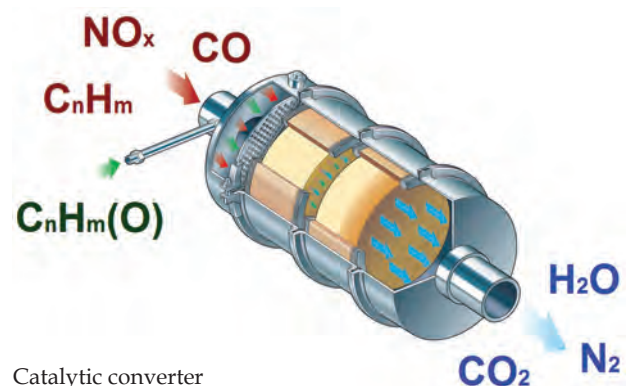
Operating temperature range – 150–600 °C



Pd/Co-Ce/cordierite catalytic block

### Advantages

The catalyst-based technology enables reducing 2–3 times the content of platinum metals as compared with counterparts without compromising the effectiveness. The catalysts are characterized by a low temperature of high conversion of toxic components (170–300 °C) and a high resistance to sulfur compounds



Catalytic converter

Stage of Development.  
Suggestions for Commercialization

IRL3, TRL4

Batches of catalyst are manufactured upon request

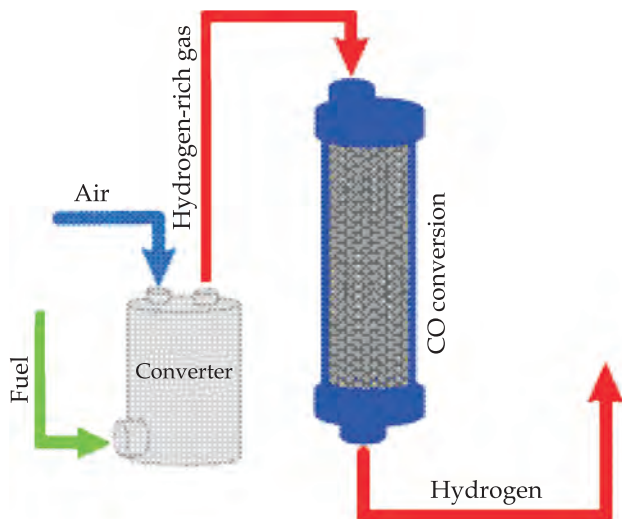
IPR Protection

IPR2

### Contact Information

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## CATALYST FOR REMOVING CARBON MONOXIDE FROM HYDROGEN-RICH GAS MIXTURE



### Areas of Application

Catalyst for fine purification of hydrogen-rich gas mixtures from CO can be used as fuel for environment friendly transport, in metallurgy, chemical, food, pharmaceutical industries, space, and defense industries

### Specification

The catalyst provides fine purification from CO (up to 50 ppm) of hydrogen-rich mixtures obtained from any organic crude. CO is removed by its selective oxidation on the catalyst surface at a temperature of 100–140 °C and an atmospheric pressure

### Advantages

As compared with counterparts, the catalyst does not contain precious metals; it is cheaper and has a higher thermal and mechanical stability

### Stage of Development. Suggestions for Commercialization

IRL5, TRL4  
Batches of catalyst are manufactured upon request

### IPR Protection

IPR3

### Contact Information

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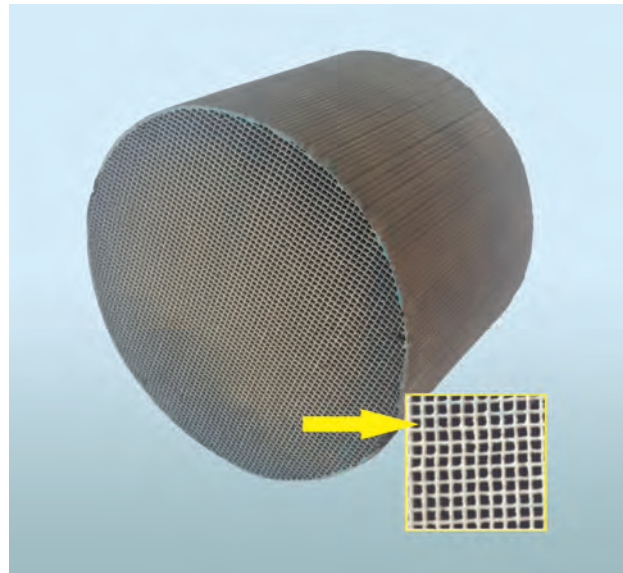
## CATALYST FOR SELECTIVE REDUCTION OF NITROGEN OXIDES IN OXYGEN-RICH EXHAUST GASES

### Areas of Application

The catalyst is to be used for neutralization of nitrogen oxides in exhaust gases emitted by lean-burn engines, diesel generators, etc.

### Specification

Ceramic honeycomb-structured block matrix made of synthetic cordierite; purification from nitrogen oxides is  $\geq 95\%$  at 250 – 400 °C; reducing agents are oxygenates, hydrocarbons; silver content is  $0.5 \pm 0.02$  wt. %



Ag/Al<sub>2</sub>O<sub>3</sub>/cordierite block catalyst

### Advantages

As compared with counterparts, the block catalyst has more accessible active components, a higher performance, a lower gas-dynamic resistance, and a reduced content of precious metals

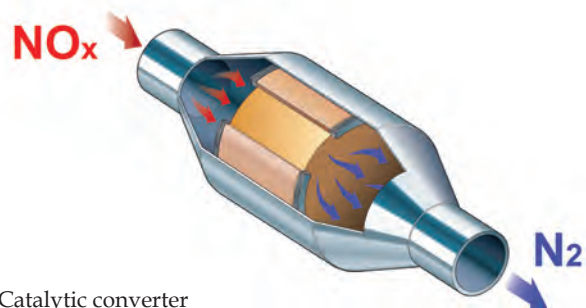


Application: purification of exhaust gases of diesel generators

### Stage of Development. Suggestions for Commercialization

IRL3, TRL4

Upon request, batches of block catalyst and recommendations on the use are provided



Catalytic converter

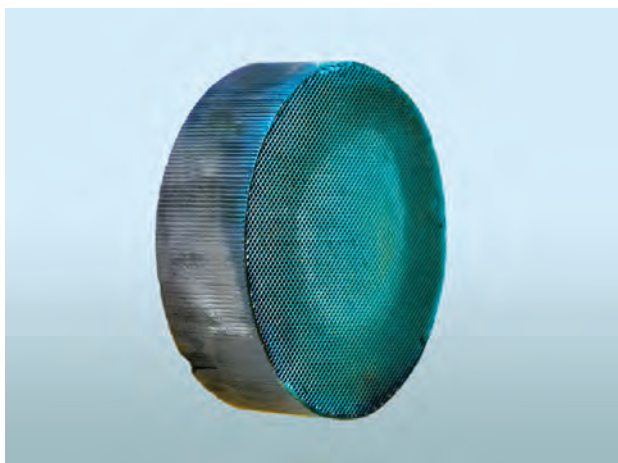
### IPR Protection

IPR2

### Contact Information

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## CATALYSTS FOR DEEP OXIDATION OF HYDROCARBONS



Catalyst appearance



Catalytic heat generators (CHG), combustion chamber of gas turbine

### Areas of Application

This catalyst is to be used in chemical, petrochemical, and metallurgical industries in systems for catalytic purification of exhaust gases from hydrocarbon impurities and for combustion of gaseous hydrocarbon fuels in industrial and household catalytic heat generators

### Specification

Fireproof ceramic honeycomb-structured blocks (cordierite, kaolin-aerosil) coated with catalyst; the content of active ingredient (manganese or cobalt oxides) is 3–7 wt.%; stable activity (100% CH<sub>4</sub> conversion is achieved at a temperatures of 650–750 °C) in deep oxidation reaction of methane during repeated cycles of in laboratory conditions; thermal stability of up to 900 °C

### Advantages

In comparison with known counterparts this catalyst has a better adhesion of second carrier (Al<sub>2</sub>O<sub>3</sub>, ZrO<sub>2</sub>) to the block material, a cheaper cost due to the absence of precious metals, a lower consumption of active ingredient due to its even distribution on the surface of secondary carrier, and a higher mechanical strength (up to 50 MPa) and fire resistance

### Stage of Development. Suggestions for Commercialization

IRL3, TRL4  
The product and recommendations on its use are provided upon request

### IPR Protection

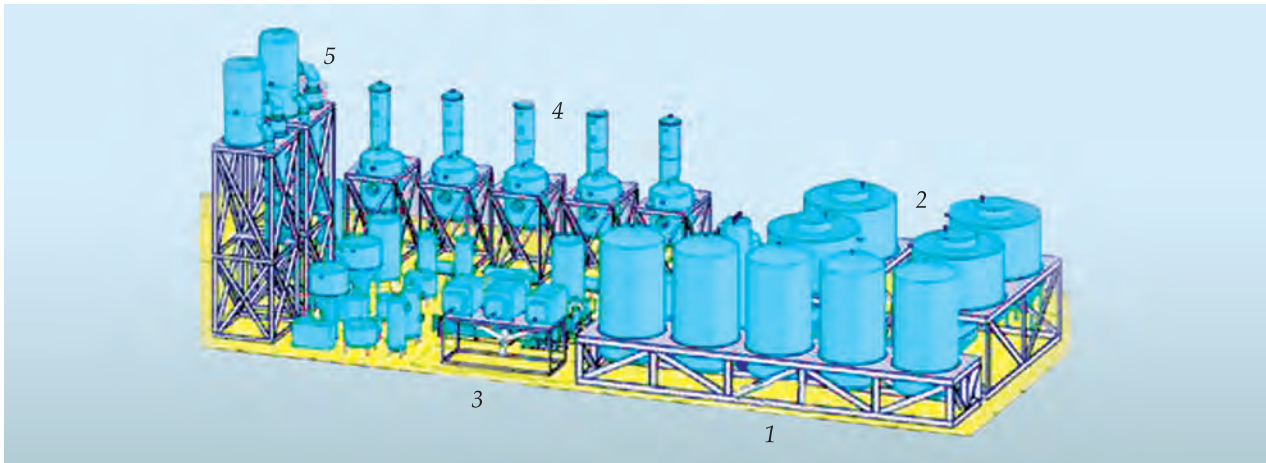
IPR1, IPR3

### Contact Information

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## CLOSED-CIRCUIT WATER TREATMENT PLANT



Closed-circuit mine water treatment plant with a capacity of 150 m<sup>3</sup>/h: 1 – storage tanks; 2 – water pretreatment facilities; 3 – reverse osmosis plant; 4 – evaporation on film evaporators; 5 – evaporation-crystallization plant



Purified water

### Advantages

The main impurities are removed from water in the form of products suitable for further use; significant reduction in energy consumption (up to 40%); extension of membrane service life up to 5–10 years (instead of 2 years on average); use of organic additives for fuel production

### Areas of Application

The plant is designed for wastewater treatment in order to get the quality suitable for its use for drinking and for various technical purposes

### Specification

The technical specifications depend on required plant capacity, chemical composition of effluents, and requirements for purified water quality. In particular, the possible options are as follows: mine water treatment; water treatment for power engineering; purification of electroplating wastes; treatment of hydraulic fracturing wastewater; treatment of spent-soap lye; and recycling of used chromate muds and solutions

### Stage of Development.

#### Suggestions for Commercialization

IRL5, TRL6

Upon request, the technology and plant are developed, warranty and post-warranty service is provided

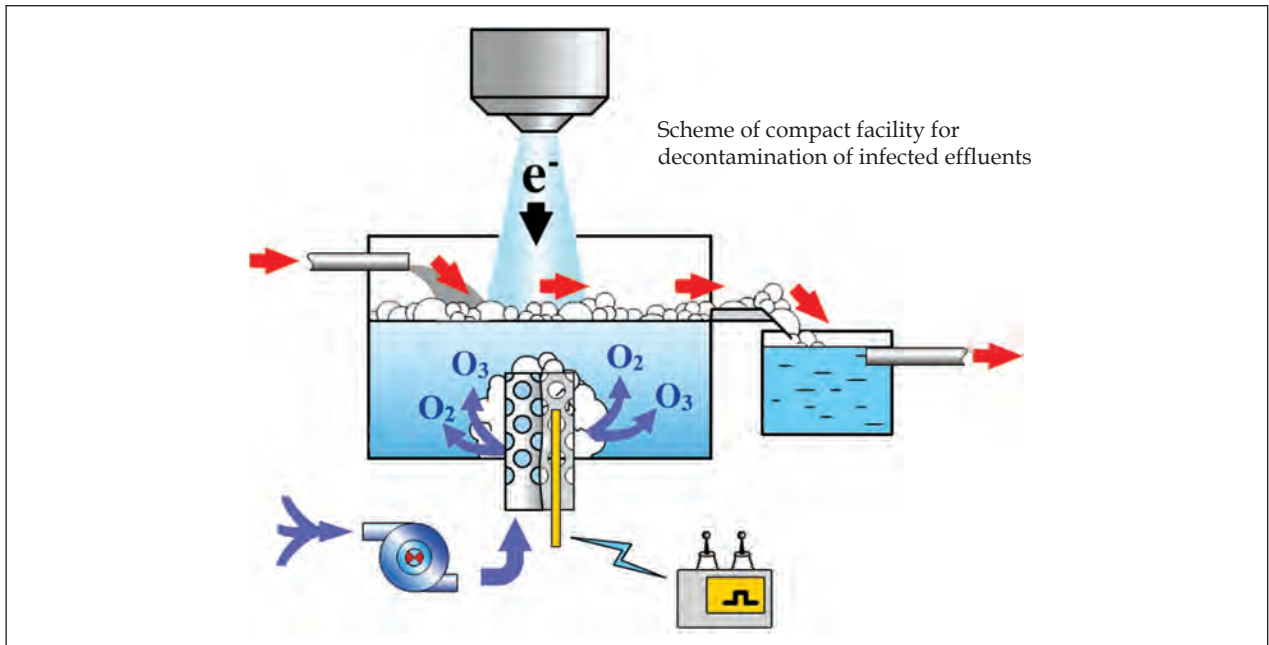
### IPR Protection

IPR1, IPR3

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## COMBINED TECHNOLOGY FOR ELECTROPHYSICAL DECONTAMINATION OF INFECTED EFFLUENTS



### Areas of Application

This is an energy-saving combined technology for decontamination of infected effluents of whatever origin (for instance, liquid waste of tuberculosis and pathogenic diseases departments of hospitals) through combining the bactericide action of electrical discharge and electronic irradiation. The technology can apply locally for disinfection at medical establishments

### Specification

The technology is based on original two-stage method for decontamination of infected fluids using special forms of electric discharge products and 400 – 500 keV electronic beams

### Advantages

The technology has no counterparts. It differs from the existing techniques with a combined use of bactericide properties of various electrophysical methods. This enables to reduce costs of engineering framework for its implementation and to create a compact disinfection facility having dimensions of about  $4 \times 4 \times 3$  m, which can be used by small medical establishments and municipal operators of sewerage systems

### Stage of Development. Suggestions for Commercialization

IRL3, TRL3  
Technology is provided

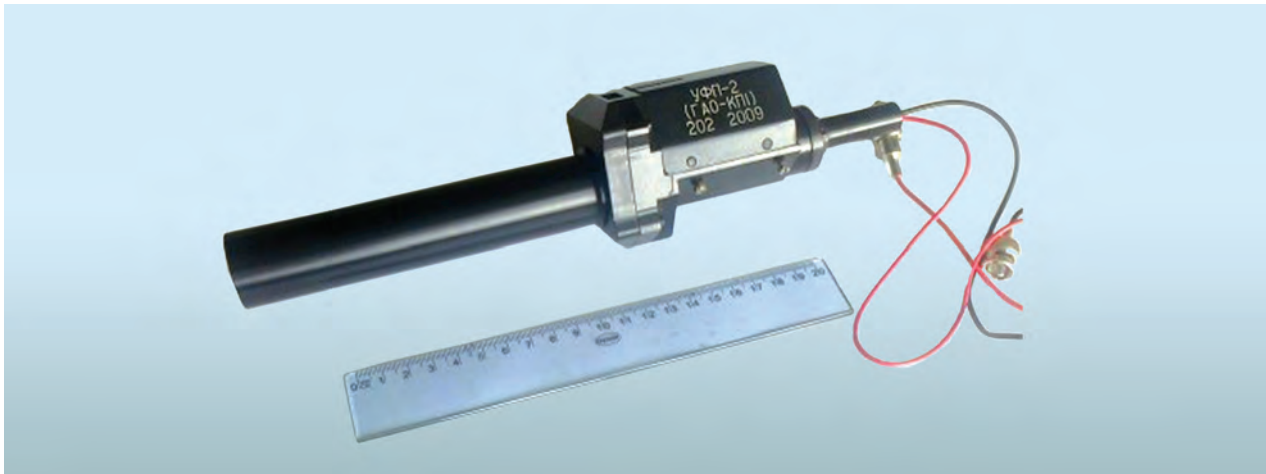
### IPR Protection

IPR1

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# COMPACT UV POLARIMETER FOR STUDYING AEROSOL COMPONENTS OF THE EARTH'S STRATOSPHERIC OZONE LAYER



## Areas of Application

The UV polarimeter enables to obtain from outer space some physical characteristics which can be used in meteorology, climate studies, and ecological innovations

## Specification

Spectral range, nm	240–290
Sensitivity, A/W	$10 \times 10^{-3}$
Accuracy, %	0.1
Power consumption, W	20
Volume, l	0.3
Weight, kg	0.5

## Advantages

The space studies of the Earth's ozone layer with the use of UV polarimeter installed on the board of artificial Earth satellite are unique in the world practice. The information obtained from them enables to clarify the mechanisms of changes in the Earth's ozone layer and those of the formation of ozone holes in order to develop and to make more efficient international efforts for preventing this disastrous phenomenon

## Stage of Development.

### Suggestions for Commercialization

IRL5, TRL5

A working model of compact UV polarimeter that can be used as a framework for creating artificial satellite-borne polarimeters to study the aerosol component of the Earth's stratospheric ozone layer

## IPR Protection

IPR1, IPR3

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## CONTROL AND MINIMIZATION OF RISKS OF PROPAGATING HUMAN WATER- AND AQUATIC ORGANISM-BORNE PARASITIC DISEASES



Trematode metacercaria in fish muscles

### Areas of Application

Reduction of the risk of human parasitic diseases, environment protection, and sustainable development

### Specification

The key objects for monitoring (certain groups of aquatic organisms, water samples from specific habitats, etc.) and complex methodological approaches provide a basis for a system of measures to reduce the risk of human water- and aquatic-organism borne parasitic diseases

### Advantages

The advantages of proposed methodology in comparison with other control procedures is an combination of hydrobiological, parasitological, and sanitary-epidemiological approaches into a comprehensive methodology that enables to take into account the key abiotic and biotic regulatory factors

### Stage of Development.

#### Suggestions for Commercialization

IRL3, TRL2

The research based on the proposed method is carried out upon request

### IPR Protection

IPR1, IPR3

### Contact Information

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## DRILLING TOOL FOR HOLE SAMPLING IN SANDY SOILS

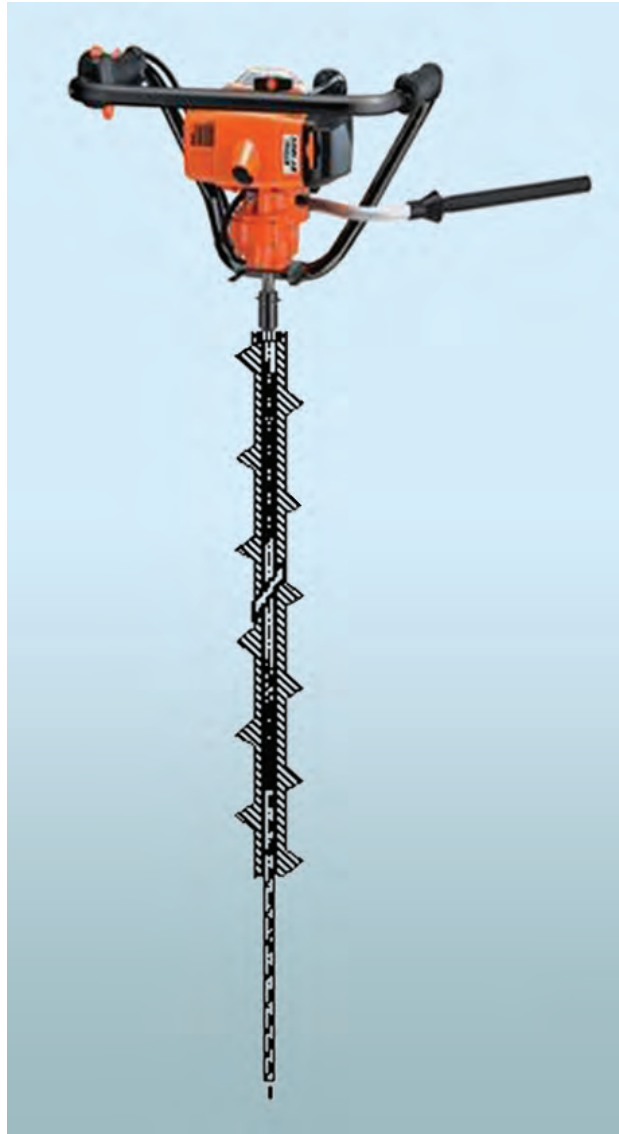
### Areas of Application

The device is used for drilling small holes in dry sandy soils; measuring temperature, thoron and radon content; sampling gases from holes; and for carrying out environment studies

### Specification

The tool is used to obtain 1 m or deeper blast holes (depending on engine power).

Weight without engine, kg      2.2  
 External dimensions, m      1.14 × 0.04



### Stage of Development. Suggestions for Commercialization

IRL7, TRL6  
 Upon request, the device is manufactured, supplied, and maintained during the warranty period; staff training is provided

### Advantages

The tool enables prevention of dry soil collapse and free movement of measuring device into the blast hole; improves productivity of geological works

### IPR Protection

IPR2

### Contact Information

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## EQUIPMENT FOR TIRES RECYCLING USING THE OZONE TECHNOLOGY



Ozone technology for tires recycling



Stream Ozone™ industrial ozone generators

### Areas of Application

The equipment is designed for disposal of waste tires and production of rubber crumb used for manufacturing reclaimed rubber, minor rubber goods (carpets, rugs, etc.), asphalt, European-type roofing felt, and composite materials

### Specification

The laboratory prototype has the following characteristics:  
capacity of up to 50 tires per day;  
rubber destruction of 85–90%;  
fine (less than 1 mm) crumb output of 15% of total crumb weight;  
and power consumption of 250 kW per ton of tires

### IPR Protection

IPR1

### Advantages

The equipment has the following advantages over the conventional equipment for mechanical tire recycling: 2-3 times less power consumption; a decrease in the number of recycling stages; a low amortization of working parts of the equipment; a high quality of rubber crumb having a more developed surface and a high purity

### Stage of Development. Suggestions for Commercialization

IRL5, TRL4

Seeking investors and partners for upgrade of technology, transition from laboratory prototype to industrial one, and production of industrial equipment

### Contact Information

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## FISH-PASSING FACILITY FOR RIVER SECTIONS SHALLOWED AS A RESULT OF DRAWING-OFF HPS OPERATION

### Areas of Application

The facility is to be used for enabling fish passage to spawning sites in the case of river shallowing as a result of operation of small drawing-off hydropower station and the appearance of obstacles to fish migration, like rapids and small waterfalls

### Specification

The fish ladder is a wooden tray narrowing downward, with transverse partitions located alternately on each side. The ladders are installed in the places critical for fish passage (rapids or drops) with a maximal height of fish elevation of up to 2 m

### Advantages

The fish ladder can be installed in almost any place of river without disrupting the natural stream bed; it is cheap, reusable, environment friendly, does not require any heavy equipment for installation

### Stage of Development. Suggestions for Commercialization

IRL3, TRL4

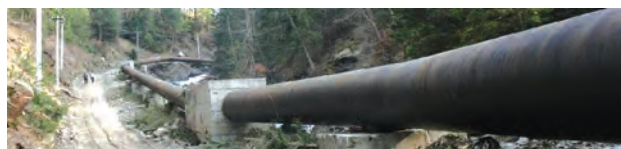
Patent sale; consultation services regarding the installation of fish ladders and control of their effectiveness are provided

### IPR Protection

IPR3

### Contact Information

*Oleksandr Ye. Usov*, Institute of Hydrobiology of the NAS of Ukraine;  
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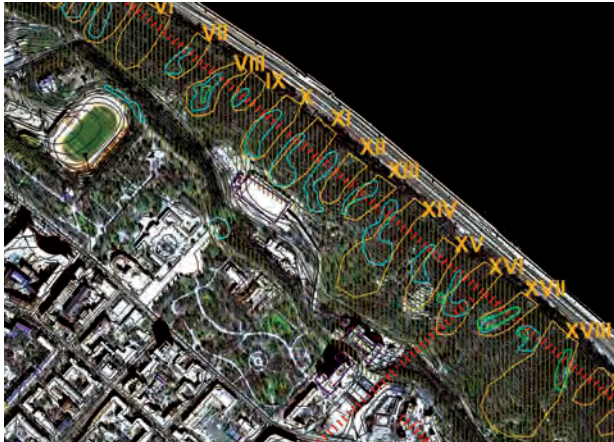


River shallowed as a result of drawing off



Spawning run of trout

## FORECASTING OF LANDSLIDES USING MULTISPECTRAL SATELLITE IMAGES



Fragment of the resulting maps of Central Dnieper landslide zone, Kyiv city



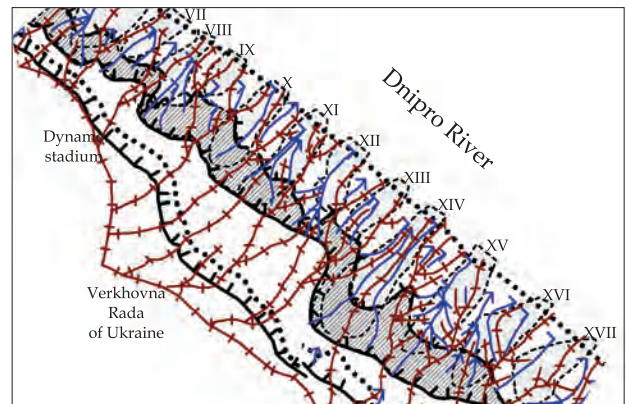
Fragment of satellite image of the Zamkova Hora with high landslide risk areas selected

### Areas of Application

The method is to be used for identifying and forecasting landslide-prone areas to prevent activation of landslides within urban areas and areas exposed to anthropogenic load, which leads to significant environmental problems and financial losses

### Specification

The forecast results are the Geographic Information System (GIS) for landslide-prone areas and some areas of possible landslide activation using multispectral satellite data, analysis of morphodynamic surface by means of the digital elevation model, and analysis of changes in anthropogenic load in the monitoring mode



Morphodynamic analysis of Central Dnieper landslide zone, Kyiv city: 1 – landslide and its number; 2 – drainage grid; 3 – ridge lines; 4 – upper slope brow; 5 – lower slope brow; 6 – slope bend; 7 – landslide risk area

### Advantages

Advantages of the multispectral satellite images over the similar ground observation data are better visibility, efficiency and a relatively low cost of this method, as well as creation of GIS for the landslide areas

### IPR Protection

IPR2

### Stage of Development. Suggestions for Commercialization

IRL6, TRL6

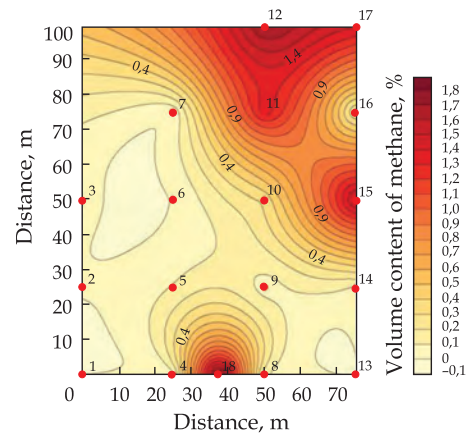
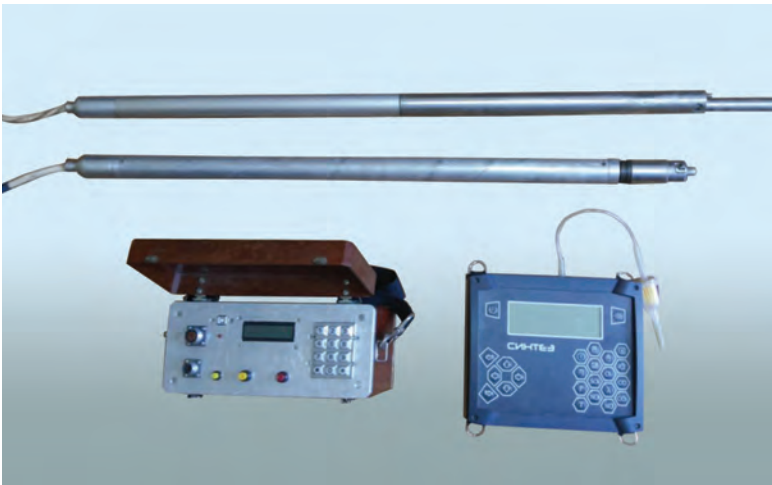
Upon request, the works for landslide prevention can be done for planning, civil engineering, and government bodies and city public administrations

### Contact Information

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## HARDWARE AND METHOD COMPLEX FOR ECOLOGICAL ENGINEERING SURVEYS OF SOLID WASTE LANDFILLS



Example of methane concentration determination in surface SWL

### Areas of Application

The complex is to be used for surface, subsurface and borehole measurements of methane and carbon dioxide concentration in the solid waste landfills (SWL); borehole measurements of engineering geophysical parameters and landfill cross section (clay insulating layers – wastes – natural ground)

### Advantages

There are no counterparts to be used for combined ecological and engineering-geophysical surveys of landfills in the world market; the hardware, result interpretation support, and software are customizable to any specific object; real-time in-situ measurement of a wide set of parameters without sampling

### Specification

The complex consists of radioactive log hardware, CH<sub>4</sub> and CO<sub>2</sub> concentration meter, and methodological support for results interpretation.

The following parameters are measured: concentration of CH<sub>4</sub> and CO<sub>2</sub> within the range of 0–100%; density, moisture, porosity, etc.

### Stage of Development.

#### Suggestions for Commercialization

IRL5, TRL6

Piece production of hardware upon request; seeking partners for commercial production and wide-scale introduction of the complex

### IPR Protection

IPR1, IPR2, IPR3

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## INCREASING THE NATURAL FISH PRODUCTIVITY OF WATER BODIES



### Areas of Application

The method is to be used in aquaculture and fish farms

### Specification

The method for increase natural fish productivity is based on the hydrological, hydrochemical, and hydrobiological studies through targeted formation of natural fodder base, selection of optimal fish species, their proportion, and measures to intensify fish growth (the use of modern stimulators, immunomodulators, micronutrients, etc.)

### IPR Protection

IPR2

### Advantages

The proposed method enables to increase natural fish productivity of water reservoirs up to 1.0–3.0 t/ha. In the case of artificial feed, the fish yield can grow up to 3.0–7.0 t/ha; in the recirculation system, it can reach 0.1–0.5 t/m<sup>3</sup>

### Stage of Development. Suggestions for Commercialization

IRL9, TRL9

Upon request, recommendations on the use of the most cost-effective method for increasing fish productivity for each water reservoir are developed

### Contact Information

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## LOW-TEMPERATURE TECHNOLOGY FOR NEUTRALIZATION OF PERSISTENT ORGANIC POLLUTANTS

### Areas of Application

The technology is to be used for neutralization of persistent organic pollutants (POPs) at low temperatures at enterprises of chemical and other industries

### Specification

The technological process is carried out at 80 °C under the action of sodium methoxide on chloroorganic compound in the presence of 0.003–0.005 mol% catalyst in solvent. Only standard equipment is used in the technology

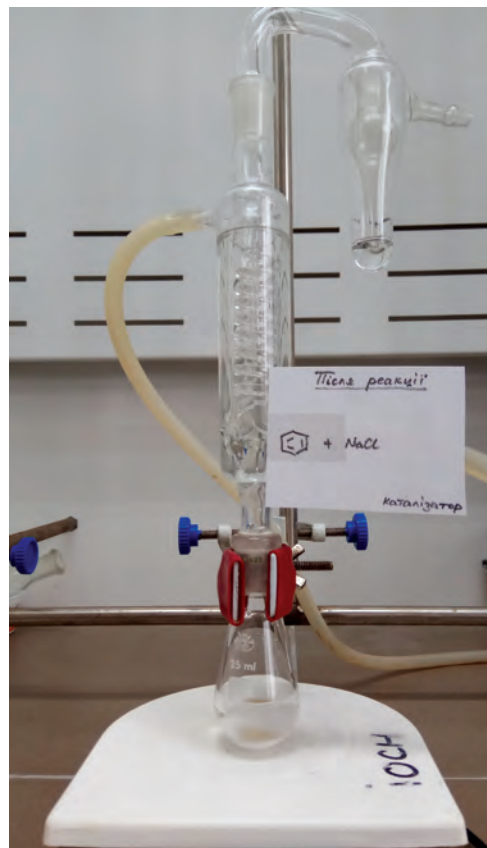
### Advantages

The technology has no world analogues. It enables the neutralization of POPs (hexachlorobenzene, dioxins, polychlorobiphenyls, DDT, DDE) at low temperatures (under 80 °C). As compared with the high temperature technologies (1100–1200 °C) the new method makes it possible to save energy, to refuse from absorbers of volatile products, which simplifies the process, and to proceed to direct absorption and neutralization of hazardous substances (for example, dioxines)

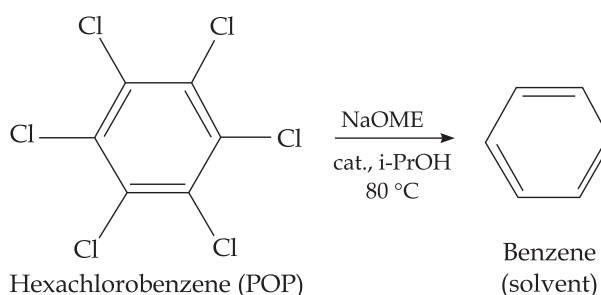
### Stage of Development. Suggestions for Commercialization

IRL3, TRL3

The laboratory technology is ready.  
The implementation of industrial technology needs preparatory works



Reaction mixture after hexachlorobenzene neutralization



Neutralization of hexachlorobenzene

### IPR Protection

IPR1, IPR3

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## MEANS OF INTENSIFICATION OF WATER BODIES SELF-REMEDIATION



A lake treated with material in summertime



A garden pond (treated with material for 5 years)

### Areas of Application

The means are to be used for protecting the natural water reservoirs from pollution and algae overgrowth, increasing the fishery productivity, and for ensuring the ecological safety

### Specification

The material for water treatment is a modified natural aluminosilicate. It has a low plastic viscosity and forms a stable gel in water. It intensifies the photocatalytic processes resulting in producing active forms of oxygen, optimizing the oxidation of organic pollutants and the retention of heavy metal ions, and improving conditions for life and growth of aquatic organisms. To intensify the self-remediation of water bodies the material suspension ( $0.1 \div 0.3\%$ ) is pulverized above the water surface, alongshore, 2–3 times in summertime

### Advantages

The materials provide a high degree of water purification from organic pollutants, which makes it possible to omit the herbicides and to enhance the productivity of fish (trout, baster, etc.) farming. The use of natural minerals results in a cheap cost of technology

IPR Protection

IPR1

### Stage of Development. Suggestions for Commercialization

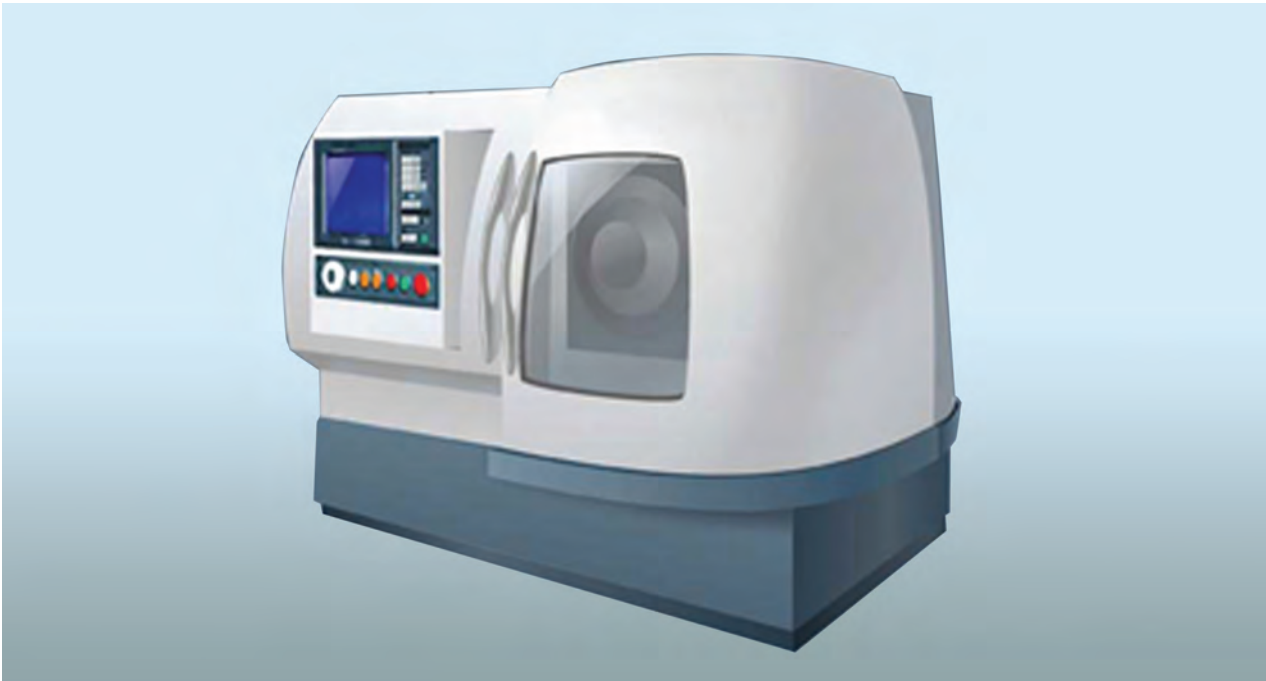
IRL8, TRL6

Materials and technology are ready for implementation in full-scale production and distribution, upon request

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## MEDWASTE MEDICAL WASTE TREATMENT COMPLEX



### Areas of Application

The complex is designed for the treatment of potentially contaminated solid medical waste

### Specification

Thermal pyrolysis: decomposition occurs at a high temperature without oxygen;  
waste processed: various medical wastes

Cycle duration, min	180
Heating method	Gas
Capacity at a humidity of 10%, kg/h	10–20
Power consumption (engine), kW	10
Weight, kg	500

### IPR Protection

IPR1

### Advantages

This technology enables preventing any contamination of air and surface water with hazardous substances and pathogenic microorganisms, produces low emissions; has an option of liquid fuel production

### Stage of Development.

#### Suggestions for Commercialization

IRL3, TRL5

Prototype; investment project for joint production; seeking for partners for joint investment project; prototype is provided and tested on the developer's site; search for sales markets in cooperation with investor

### Contact Information

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## MELIORATION OF WATER RESERVOIRS



### Areas of Application

The method is to be used in water management and fishery for improvement of ecological state of water ecosystems, private lease, and recreational use of water bodies

### Specification

The method is based on the biological reclamation with the use of herbivorous fish and the mechanical reclamation by mowing of higher aquatic vegetation and withdrawal of bottom sediments

### Advantages

The method enables quick and low-cost creation of optimal conditions for water use and inhabitation of fish and other aquatic organisms in water bodies. Using new high-performance fish hybrids enables to process up to 20 t/ha of bottom sediments (detritus and silt) annually, to inhibit the growth or to completely eliminate the higher aquatic vegetation. Also, the method provides the advanced technique for withdrawal of bottom sediments

### Stage of Development. Suggestions for Commercialization

IRL9, TRL9

Upon request, the standards for sediment control are developed and recommendations on the use of the most cost-effective melioration methods including manual, mechanical, or biological reclamation are provided for each water reservoir individually

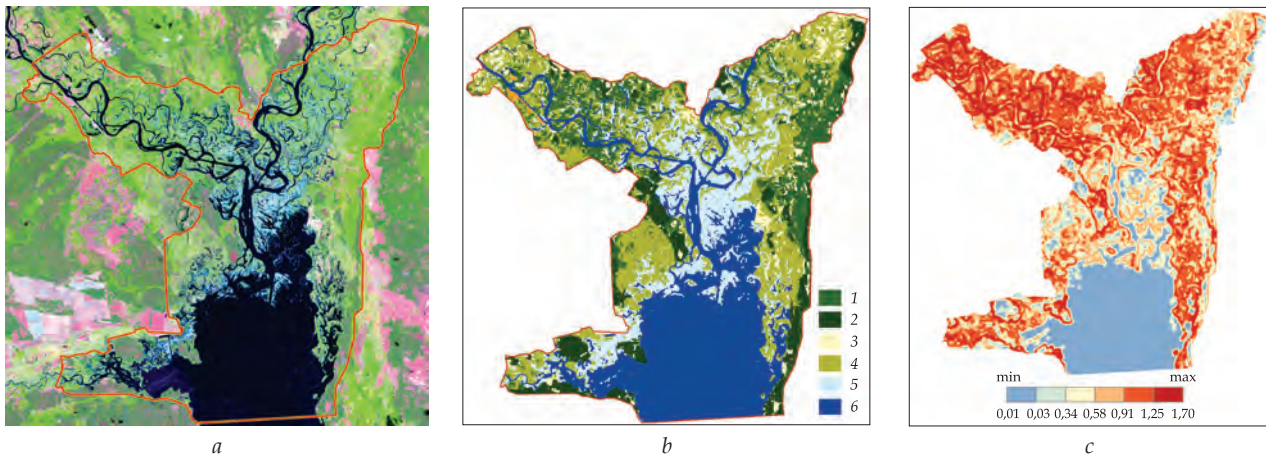
### IPR Protection

IPR2

### Contact Information

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## METHOD FOR REMOTE ASSESSMENT OF ECOLOGICAL STATE AND WATER QUALITY OF INLAND RESERVOIRS



Decoding of the satellite images and mapping of the biotopes of the inland water (e.g. top of the Kyiv reservoir): *a* – the part of the Landsat 8 satellite image (2015-08-28); *b* – map of the biotopes; *c* – map of the landscape diversity (e.g. Simpson’s index)

### Areas of Application

The comprehensive assessment of inland reservoir ecological state is used for long-term monitoring and forecasting based on present-day and retrospective Earth remote sensing data and ground-based observations

### Specification

The deliverables are: set of thematic maps of water reservoir state (biotope types, vegetation and water indexes, surface temperature, and landscape diversity parameters) with high and moderate spatial resolution; statistical tables with areas of selected components and ground-based observation data; and graphic results of simulation and forecast of reservoir condition

### Advantages

The method surpasses the analogs in terms of more simple and fast assessment of aquatic ecosystem condition; it covers larger areas and enables retrospective study of inland reservoir condition. Also, it enables to detect shallow aquatic-landscape complexes that not only affect the reservoir hydrological regime, but also condition physical, chemical, and hydro-biological characteristics of aquatic environment

### Stage of Development.

### Suggestions for Commercialization

IRL6, TRL5

The ecological state of particular reservoir or group of reservoirs is studied upon request

### IPR Protection

IPR2

### Contact Information

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## METHODS AND EQUIPMENT FOR REDUCING NITROGEN OXIDES EMISSIONS BY BOILERS



### Areas of Application

The methods and equipment are to be used by power engineering companies and communal enterprises for boilers of thermal power stations, central heating and power plants, and powerful boiler stations. Its application enables to reduce NO<sub>x</sub> emissions from natural gas combustion to meet the European standards

### Specification

The approach is based on the use of staged combustion burners, recirculation (including into fuel), staged combustion cycle or by simultaneous use of several methods. The staged combustion burners:

$$\alpha = 1.2$$

Control factor 5

$$\text{NO}_x \leq 100 \text{ mg/nm}^3$$

$$\text{CO} \leq 100 \text{ mg/nm}^3 \text{ at } 3\% \text{ O}_2$$

### Advantages

The lowest capital costs among the counterparts; implementable on existing 4–1000 MW boilers installed as long as 40–50 years ago.

The rehabilitation extends service life of boilers by 15–20 years; the method is implementable in the course of repair works

### Stage of Development.

#### Suggestions for Commercialization

IRL7, TRL8

Upon request, equipment is manufactured, supplied, mounted, commissioned, and serviced during the warranty period; staff training is provided

### IPR Protection

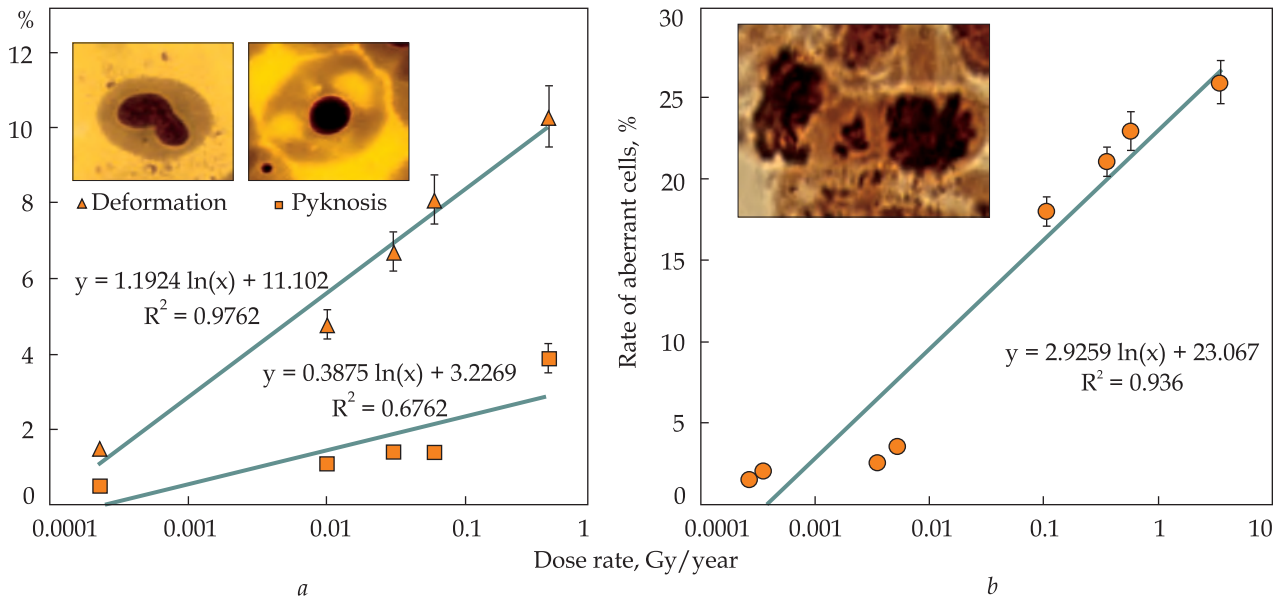
IPR3

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# METHODS FOR BIO-INDICATION OF ECOLOGICAL STATE OF WATER BODIES UNDER THE EFFECT OF LONG-TERM RADIOACTIVE CONTAMINATION



Dependence of frequency of injured red cell nuclei of peripheral blood of common rudd (a) and dependence of amount of aberrant cells in embryo tissues of pond snail (b) on radiation dose

## Areas of Application

The method is to be used by nuclear fuel cycle enterprises and regulatory bodies in the field of nuclear industry and environment protection for monitoring the state of aquatic ecosystem under conditions of radioactive contamination to ensure the ecological safety in nuclear power engineering and the protection of environment from radiation

## Specification

The method is based on the use of cytogenetic parameters (rate of aberrant cells) of embryonic tissues of freshwater pond snails and root meristems of higher aquatic plants, as well as of hematologic parameters (rate of deformations and pyknosis of peripheral blood red cell nuclei) of freshwater fish in order to determine the biologically significant levels of contamination of aquatic ecosystem components with main dose-forming radionuclides

## Advantages

The developed methods and criteria adequately show the level of radiation impact and detect the early damages of the most sensitive components of biotic communities in aquatic ecosystems exposed to radiation

## Stage of Development. Suggestions for Commercialization

IRL5, TRL3  
The method for monitoring the quality of aquatic environment affected by nuclear fuel cycle enterprises is developed upon request

## IPR Protection

IPR2

## Contact Information

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## MODULAR SYSTEM FOR SEABED AND BOTTOM WATER STUDIES



### Areas of Application

The system is to be used for bottom water sampling, sealing, degassing, bottom sediment sampling, and for temperature measurement at multiple levels of bottom sediments

### Specification

Simultaneous water sampling and measurement of geological parameters at a depth of up to 2000 m; the complex is equipped with platforms to mount additional instruments for measuring chemical and physical parameters and with a bottom water degasser and a bottom sediment sampler.

Sampling at depths, m	≤2000
Temperature measurement, °C	0...+30
Thermal inertia, c	≤10
Value of the smallest graduation, °C	≤±0.05

### Advantages

The complex has an easily modifiable configuration in order to be adapted in accordance with the specific task; highly integrable hardware enables to increase the reliability of geological data and to reduce the vessel time

### IPR Protection

IPR2

### Stage of Development.

#### Suggestions for Commercialization

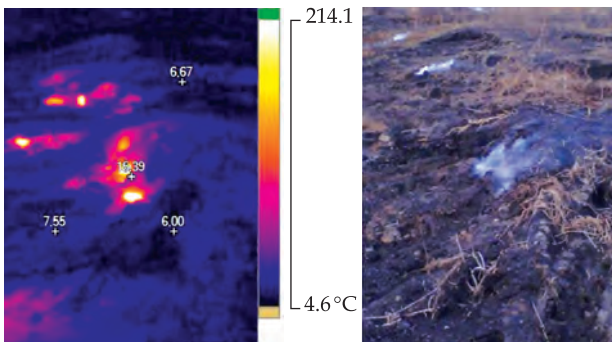
IRL6, TRL6

Upon request, the device is manufactured and supplied; maintenance during the warranty period and staff training are provided

### Contact Information

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# MONITORING OF THE STATE OF PEATLANDS FOR IDENTIFYING FIRE-DANGEROUS AREAS USING REMOTE METHODS



Latent underground fire seats in peatland areas after completion of fire-fighting operations

## Areas of Application

The method is to be used for monitoring the fire-dangerous areas of peatlands to prevent fire outbreaks and for detecting hidden residual hot spots and fire seats after fire-fighting operations

## Specification

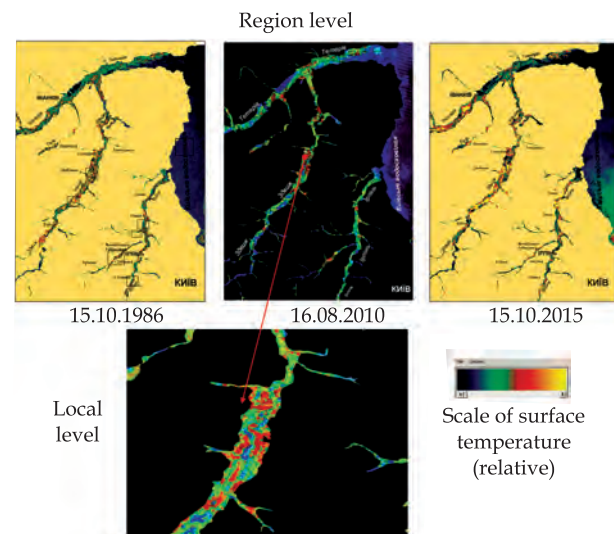
The method is based on monitoring of thermal anomalies in peatlands using time series of thermal channels of medium spatial resolution multi-channel satellite images (seasonal, annual) and IR imager field measurements. The deliverables are outlined peatland contours, calculated absolute temperature of peatland surface, identified fire-dangerous areas submitted as GIS

## Advantages

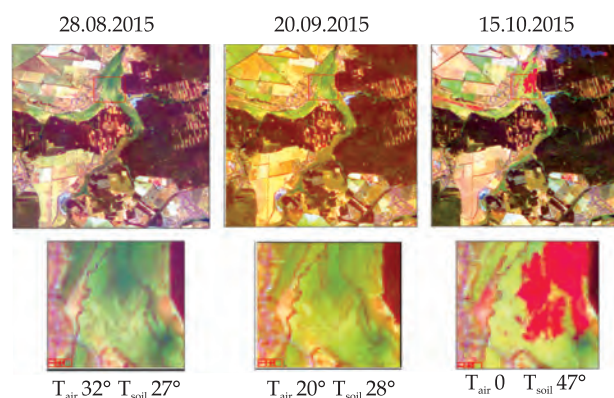
As compared with the counterparts, this method enables ongoing monitoring of the thermal state of peaty soils, as well as rapid detection of fire outbreak areas and residual thermal anomalies after fire-fighting operations due to the use of a complex of ground-based IR imagers and airborne thermal surveys

## IPR Protection

IPR2



Monitoring of the thermal field of flood plain surface (Irpin, Zdvizh, and Teteriv Rivers) based on the data of Landsat-5, 7, 8).



Changes in remote image of Chornohorodka peatland based on Landsat data for three months of 2015

## Stage of Development.

### Suggestions for Commercialization

IRL5, TRL6

Upon request, a survey for determining the thermal state of individual peatlands and fire hazard level can be carried out for environment protection organizations, as well as for structural units and departments of the Ministry for Emergency Situations

## Contact Information

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## MULTIBIOSENSOR FOR DETECTING TOXIC SUBSTANCES IN WATER SAMPLES



Measuring device with multibiosensor and flow-through system

### Areas of Application

The device is to be used for measuring concentrations of toxic compounds as part of ecological monitoring of water reservoirs and soil

### Advantages

No commercial analogues are known. In comparison with the similar laboratory prototypes the proposed multibiosensor is portable and suitable for measurements in field conditions with the possibility of distinguishing between different classes of toxins, has a low price, and does not require any sample pretreatment

### Specification

Analyte	Heavy metal ions	Pesticides
Bio-selective elements based on:	Urease, glucose oxidase, acetylcholinesterase, butyrylcholinesterase	Acetylcholinesterase, butyrylcholinesterase
Butyrylcholinesterase	$10^{-6} - 5 \times 10^{-3}$	$3 \times 10^{-11} - 5 \times 10^{-4}$
Storage stability, months	4	4
Duration of analysis, min	20	20
Measurement error, %	≤15	≤15

Stage of Development.  
Suggestions for Commercialization

IRL5, TRL4

The device is manufactured upon request; seeking partners for the mass production

IPR Protection

IPR3

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## MUNICIPAL WASTEWATER TREATMENT TECHNOLOGY FOR SMALL CITIES OF UKRAINE

### Areas of Application

The technology is to be used for wastewater treatment

### Specification

The developed technology for wastewater treatment plants includes: replacement of pre-settling tanks with anaerobic EGSB-reactors having an extended layer of granules and sand as carrier; use of aero-filter-type facilities for aerobic purification; creation of conditions for permanent removal of partially disrupted organic particles from EGSB-reactor to the next stage of treatment; discharge of excess sludge from the aerobic stage of treatment to EGSB-reactor; use of purging channel for nitrification and baffled anaerobic reactor; use of highly-loaded sludge ponds; and stream aeration using submersible slurry pumps



Rehabilitated sludge bed



Anaerobic bioreactor



Aerobically stabilized sludge with a moisture content of 75%

### Advantages

The anaerobic treatment of wastewater in psychrophilic conditions provides a significant (4–5 times) reduction in the share of dry matter in sludge a good filtration properties, with the area of sludge bed decreasing 10 times. It enables designing inexpensive water treatment facilities with power consumption less than 0.2–0.5 kWh per 1 m<sup>3</sup> treated wastewater for greenfield construction

Stage of Development.  
 Suggestions for Commercialization  
 IRL5, TRL7  
 Process flowchart for particular effluents is developed and staff training is provided upon request

IPR Protection  
 IPR3

### Contact Information

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## OCTOKOPTER-TYPE SYSTEMS FOR REMOTE GAMMA-SPECTROMETRIC SCANNING OF THE EARTH'S SURFACE FROM AIRBORNE VEHICLES



### Areas of Application

The onboard equipment is designed for remote detection and mapping of radioactive anomalies, as well as for development of orthophoto maps

### Specification

Dimensions, mm	1040 × 1040
Load capacity, kg	<7.5
Velocity with a load of up to 1.5 kg, m/s	<10
Maximum flying time, min	20 – 25
Flying height, m	10 – 300

### Characteristics of gamma spectrometric complex:

Dimensions of cylindrical basic detector:	
Height, mm	63
Diameter, mm	63
Weight of basic detector, g	950
Number of basic detectors, pieces	5
Measurement range of equivalent dose rate (EDR), $\mu\text{Sv/h}$	0.1 – 5000
Limit of permissible basic relative error of EDR measurement, %	20
Detection unit dimensions:	
Diameter, mm	300
Length, mm	300
Weight of detection system, kg	7.5

### Stage of Development. Suggestions for Commercialization

IRL3, TRL5

Prototype; investment project for joint production; seeking for partners for joint investment project; prototype is provided and tested on the developer's site; search for sales markets in cooperation with investor

### IPR Protection

IPR1

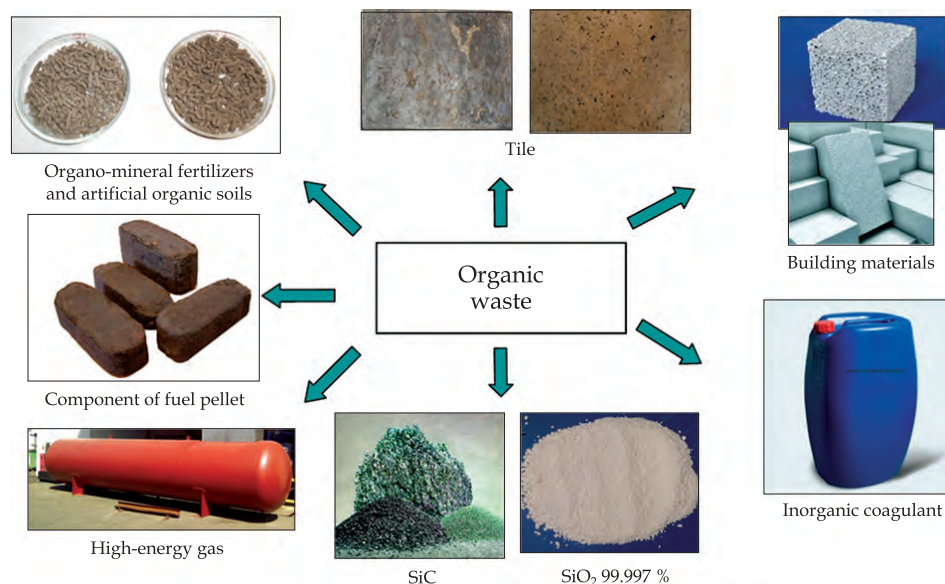
### Advantages

Low cost, low risk for operators, the ability to capture images at low altitudes near the potentially hazardous objects

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## PROCESSING OF ORGANIC WASTE INTO VALUABLE SUBSTANCES AND MATERIALS



Scheme of integrated processing technology of the organic waste

### Areas of Application

The technology is to be used for recycling plant waste into commercial products

### Specification

The integrated technology for processing plant waste includes the following stages: preparation of raw materials for further processing; targeted waste treatment to obtain a specific product; residual biomass thermal decomposition after removal of one or more products; grading of ash residue formed after heat treatment to obtain high-purity products; recovery of ash residue, if the grading stage is missing for a particular customer (fertilizers, construction materials and reagents for water purification)

### IPR Protection

IPR1

### Advantages

Unlike the world existing technologies for recycling plant waste, majority of which is oriented towards energy generation, this one enables obtaining several high-demand products and materials (technical and microcrystalline cellulose, alcohols, furfural, hydroxybenzaldehydes, high-purity SiO<sub>2</sub>, SiC, and Si<sub>3</sub>N<sub>4</sub>) at the same time

### Stage of Development.

#### Suggestions for Commercialization

IRL5, TRL5  
Technology for processing particular biomass is developed, upon request

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## RADIATION TECHNOLOGY FOR RECYCLING AND REUSE OF WASTE POLYMERIC MATERIALS



### Areas of Application

The technology is proposed for disposal of household and industrial polymeric waste (secondary polymers) and for transformation of a reactive mass under the action of radiation for reuse in heat-resistant composite road pavement with increased strength

### Specification

The technology is based on destroying the surface of chemically neutral polymeric granules under the action of radiation with further chemical reaction with other components of bituminous asphalt in order to get a dense polymer bituminous composite for heat-resistant road pavement. The composite is sustainable within a range of operating temperature from  $-50\text{ }^{\circ}\text{C}$  to  $+120\text{ }^{\circ}\text{C}$  and has a longer service life as compared with the conventional materials



### Advantages

There are no analogs in Ukraine. The radiation technology enables the production of high-quality road pavement materials and solves a pressing ecological problem as this technology provides recycling and reuse of environmentally hazardous polymeric waste

### IPR Protection

IPR3

### Stage of Development.

Suggestions for Commercialization

IRL3, TRL3

Technology is provided

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## SHOOT PULVERIZING DEVICE FOR FIRE EXTINGUISHMENT AND GENERAL PROTECTION



Device and container for substance pulverized in parts (left) and ready for use (right)

### Areas of Application

The device is to be used for fire extinguishment and prevention of leakage of hazardous substances during natural and manmade catastrophes

### Specification

The fire extinguisher tube is charged/recharged with one-liter plastic bottle for 3–5 s.  
The range capability is from 5 to 25 m depending on composition of pulverized mixture and pulverization mode set by special charge

Weight of empty device, kg	5.5
Weight of charged device, kg	6.5

### Advantages

The principal advantage is that no special treatment of water or other fire-fighting agents is required for fire extinguishment. The device has a large range capability and a small weight. The device configuration does not require any special skills for its use. The device can pulverize untreated water, sand, soil, snow, available fine-graded materials. No need to transport the containers for fire-extinguishing substances to service station or service center for charge/recharge

### Stage of Development. Suggestions for Commercialization

IRL4, TRL4  
Seeking partners for manufacture of cost-effective device

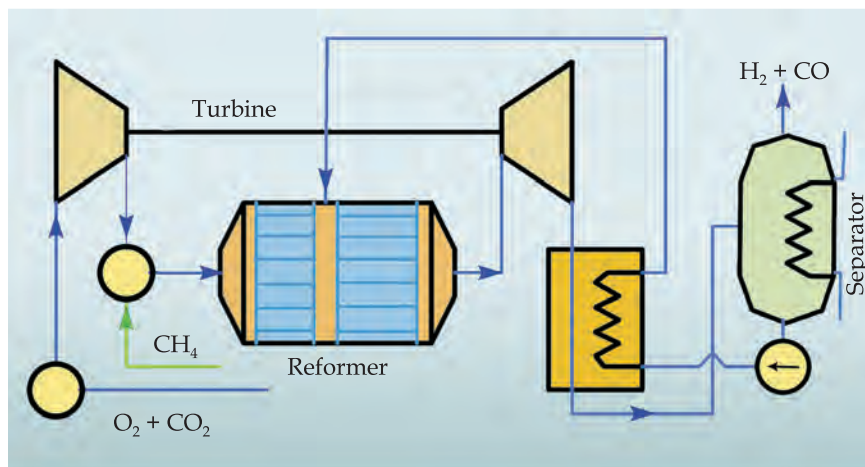
### IPR Protection

IPR3

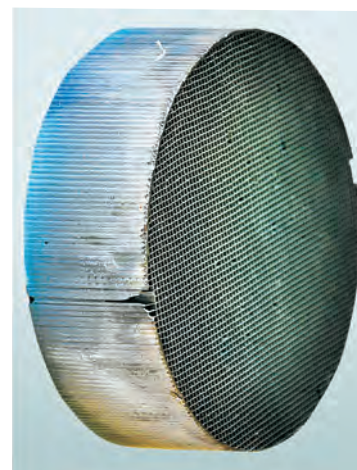
### Contact Information

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## STRUCTURED CATALYSTS FOR C<sub>1</sub>-C<sub>4</sub> ALKANES COMBINED REFORMING INTO SYNGAS



Scheme of catalytic reformer with turbine



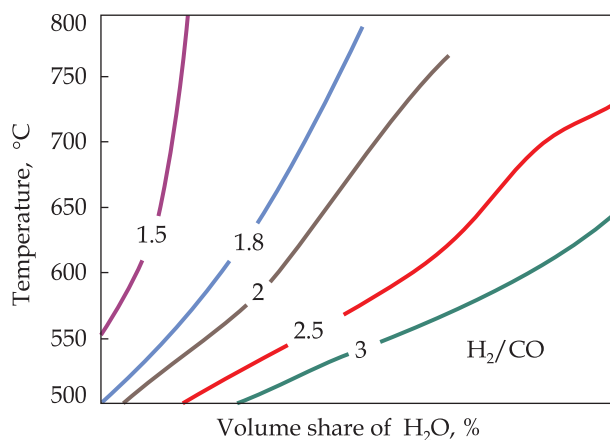
Catalyst

### Areas of Application

The catalyst is to be used for obtaining syngas by combined O<sub>2</sub>-CO<sub>2</sub>-H<sub>2</sub>O reforming of natural gas (methane and its homologues) for the further synthesis of ammonia, methanol, diethyl ether, and for Fischer-Tropsch synthesis

### Specification

This cellular structured catalyst with a low content of active ingredients and a low gas-dynamic resistance enables performing combined oxidative reforming of C<sub>1</sub>-C<sub>4</sub> alkanes involving O<sub>2</sub>, H<sub>2</sub>O, and CO<sub>2</sub>; obtaining syngas with H<sub>2</sub>/CO ratio adjustable from 1 to 3; and implementing the autothermal mode



Syngas composition diagram

### Advantages

As compared with similar catalysts, this one is cheaper, has a lower content of active components and a high productivity; it is resistible to carbonization and action of sulfur-containing compounds, has a low gas-dynamic resistance and operates within a wide temperature range (500 – 1000 °C); the catalyst does not contain precious metals

### Stage of Development. Suggestions for Commercialization

IRL6, TRL5  
Upon request, prototype is manufactured; license agreement for commercial production is made

### IPR Protection

IPR3

### Contact Information

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## TECHNOLOGY FOR AERATION STATION SLUDGE DEWATERING USING GEOTEXTILE MATERIALS

### Areas of Application

The technology is to be used for reducing the water content in aeration station sludge

### Specification

Dewatering of aeration station sludge is based on the pattern “sludge inside the container → water through geotextile material out of the container” and “sludge outside of the container → water through geotextile material into the container with ongoing water evacuation.”

The problem of regeneration of filter modules has been solved



Filtering module in BSA aerobic stabilizer

### Dewatering of aerobically stabilized sludge by plant prototype

Sample	COD, mg O <sub>2</sub> /dm <sup>3</sup>	Dry residue, mg/dm <sup>3</sup>	Suspended particles, mg/dm <sup>3</sup>
Initial sludge	10 400	11 950	10 980
Filtrate	240	860	46

### Advantages

Dewatering of aeration station sludge in the mode “sludge outside the container” has been implemented for the first time. The proposed approaches can be used to reduce the load on ground sludge treatment facilities; to deeply clean the return supernatant water supplied from silt sites to the head of biological sewage treatment process; to reduce the level of silt detention ponds for increasing their operating capacity and for minimizing the load on guard dams; to dewater the sludge accumulated by placing it in geotextile containers; and to condition the sludge of any origin (except for aggressive one)

### Stage of Development. Suggestions for Commercialization

IRL5, TRL7  
Process chart is developed and training is provided upon request

### IPR Protection

IPR3

### Contact Information

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## TECHNOLOGY FOR IMPROVING WATER QUALITY AT LARGE CASCADE RESERVOIRS BY HYDROPOWER STATION RELEASES

### Areas of Application

The technology is to be used for improving the oxygen regime of water reservoirs, preventing asphyxiation of fish and other aquatic organisms, and ensuring water quality that meets the applicable water supply and consumption standards. The scope of application covers water economy, fishery, municipal water supply, environment protection, recreation, and power engineering

### Specification

The technology (mathematical model) makes it possible to calculate the required regimes and HPS release volumes

### Means of Regulating the Oxygen Regime of Cascade Reservoirs by HPS Releases

Type of reservoir	In summertime	In wintertime
River	Increasing volumes of upper HPS releases Increasing irregularity of upper HPS releases	Increasing length of water opening in the barrage area
Pond	Intensifying water exchange in shallow areas Intensifying water dynamics	Asynchronous operation of upper and lower HPS

### Advantages

The proposed technology for regulating the ecological regime of HPS operation is feasible and does not require additional material costs

### Stage of Development. Suggestions for Commercialization

IRL5, TRL5  
The calculations of ecological regime and HPS release volume are provided upon request

### IPR Protection

IPR1, IPR2

### Contact Information

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## TECHNOLOGY FOR RAISING EFFICIENCY OF WET SCRUBBING OF PULVERIZED-COAL FIRED BOILER FLUE GASES FROM ASH



Flue gas purification



Venturi scrubber

### Areas of Application

The technology can be used for upgrading the plants for wet cleaning of flue gases of pulverized-coal fired boilers from fly ash (Venturi scrubbers) at TPPs

### Specification

The technology takes into account all significant physical phenomena taking place in the scrubbers and provides an opportunity to improve its operation

### IPR Protection

IPR2

### Advantages

The optimization of scrubber configuration and operating conditions using the proposed technology enables to reduce the amount of harmful substances emitted to atmosphere 2–3 times

### Stage of Development.

#### Suggestions for Commercialization

IRL5, TRL3

Upon request, scrubber configuration and operating conditions are optimized while developing new scrubbers or upgrading the existing ones. Recommendations are provided

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## TECHNOLOGY FOR TREATMENT OF SOLID DOMESTIC WASTE LANDFILL LEACHATE



Leachate of SDW landfill



Catalytic oxidative treatment of leachate



Discharge of purified water into environment

### Areas of Application

The proposed technology solves a very important environment and social problem, the pollution of aquifers with highly toxic leachate

### Specification

This highly-efficient technology for comprehensive treatment of landfill leachate is designed to process 1.000 m<sup>3</sup> leachate daily and involves the following stages: catalytic deep oxidative pretreatment of leachate; demineralization with the use of membranes (or in any other way); refinement in bio-pond until the applicable standards are met; and discharge of clean water into environment

### Advantages

Unlike the existing methods, this technology enables organising the full recycling of leachate to obtain purified water that meets the applicable environment standards and to solve the problem of concentrated residue that is processed into materials for cap barrier layer, road construction materials or admixtures

### Stage of Development. Suggestions for Commercialization

IRL5, TRL7  
Customized process flowchart for particular landfill is developed and staff training is provided upon request

### IPR Protection

IPR3

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# TESTS FOR DETECTION OF HEAVY METALS, NITRATES, AND CATIONIC SURFACTANTS IN LIQUID SAMPLES



Demonstration samples of test systems

## Areas of Application

The tests are to be used for laboratory and field ecomonitoring as well as for industrial and domestic application in order to detect toxic substances in drinking, tap or sewage water, juices, fruits, and vegetables

## Advantages

The proposed tests are competitive to famous brands, easy-to-use and have a long-term stability under storage conditions

## Stage of Development. Suggestions for Commercialization

IRL6, TRL7  
Upon request, tests are manufactured or developed

## IPR Protection

IPR1, IPR3

## Specification

Test	Range of detection	Test type
Fe-test	0.02–0.3 mg/l	Sorption on polyurethane foam
Cu-test	0.003–1 mg/l	Indicator paper
Mn-test	0.03–1 mg/l	Indicator film
Ni-test	0.03–1 mg/l	Sorption on polyurethane foam
Co-test	0.4–1 mg/l	Sorption on polyurethane foam
Chlorine	0.1–2 mg/l	Indicator paper
Cationic surfactant	0.1–1 mg/l	Sorption on polyurethane foam
Nitrates and nitrites	50–800 mg/kg	Indicator paper
Heavy metals	0.2–6.4 μmol/l	Indicator paper

## Contact Information

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## TEXIVOD FILTERING GEOTEXTILE MATERIALS



Flexible apron of Pozniaky pond banks with the use of *Texivod*



Flexible apron works

### Specification

The characteristics of geotextile materials meet the criteria TU V.2.7-17.2-00311444-001: 2006

Indicator	The value of indicators in grades of materials			
	Thin-T	Flat-P	Frame-K	Dimensional-O
Surface density, g/m <sup>2</sup>	60–90	300–400	400–600	500–700
Thickness at a pressure of 1 kPa, mm	0.5–0.8	2.0–2.5	5.0–6.5	15–40
Breaking load, N/r. m	>1500	>8000	>8000	>6000
Elongation at rupture, %	20–35	90–110	18–20	20–50
Filtration coefficient at a pressure of 8 kPa, m/day	>80	>160	>300	>600

### Areas of Application

The materials are to be used as inverse filters of protective walls of waterworks and drainage structures

#### Stage of Development. Suggestions for Commercialization

IRL8, TRL8  
Consultations on the use of *Texivod* material and its procurement, engineering support of related projects are provided

#### IPR Protection

IPR1

### Advantages

The developed geotextile materials are manufactured at domestic factories using domestic raw materials; they are much cheaper than the foreign counterparts and can fully or partially replace the conventional inverse filters made of natural materials. The use of geotextile materials as inverse filters in walls of hydraulic structure ensures a reliable interface stability of soil base, reduces significantly the material consumption, which is important in terms of saving of natural resources and environment protection, increases the labor productivity, and reduces the construction costs with the quality and serviceability guaranteed

### Contact Information

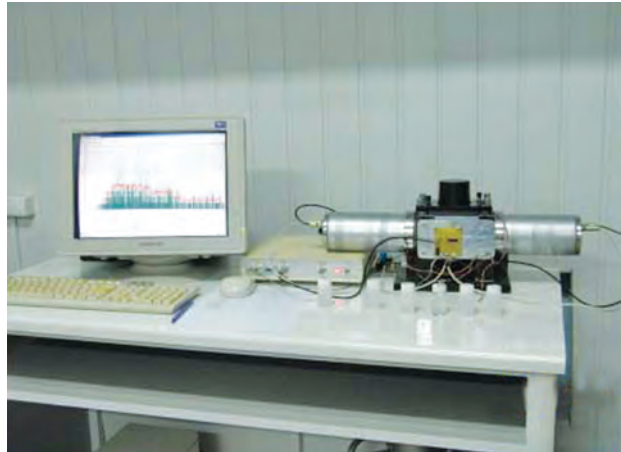
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## TRIUMF SYSTEM FOR CONTROL AND MONITORING OF TRITIUM AND CARBON-14 RADIONUCLIDES

### Areas of Application

The system is designed for measuring specific activity of tritium and carbon-14 based on their beta radiation in the environment objects, biological samples or in NPP process environment



### Specification

Efficiency of tritium detection, %	>60
Efficiency of carbon-14 detection, %	>90
Tritium self-background, cpm	<20
Carbon-14 self-background, cpm	<30
Minimal detectable tritium activity, cpm	12
Minimal detectable carbon-14 activity, cpm	8
Sensitivity, Bq/l	1
Irregularity of calibration characteristic per 1 hour of uninterrupted operation, %	≤2
Radiation energy range, eV	5–1500
Energy dependence, MeV, ±25%	0.06–1.5
Maximal statistical input load, cps	≤10 000

### Stage of Development. Suggestions for Commercialization

IRL3, TRL5  
 Prototype; investment project for joint production; seeking for partners for joint investment project; prototype is provided and tested on the developer's site; search for sales markets in cooperation with investor

### Advantages

Remote measurements and automatic control

### IPR Protection

IPR1

### Contact Information

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## VECTOR MULTIFUNCTIONAL PORTABLE STATION FOR RADIOLOGICAL CONTROL AND MONITORING



### Areas of Application

The portable station is to be used for search, localization, and rapid identification of radioactive and nuclear materials

### Specification

Energy range	From 50 keV to 3.0 MeV
Maximum input load, pulse/s	46 000
Measurement time, s	20–60
Volume activity, Bq/l	7 (Cs-137), measurement time up to 5 min
Surface contamination density, mCi / m	0.01
Measured radionuclides	K-40, Cs-137, Cs-134, Ra-226, Th-232, Am-241 and others
Maximum equivalent dose rate, Sv/year	≤10
Maximum equivalent dose, Sv/year	≤15
Weight, kg	≤5
Power supply	
from mains, V	220
from battery, hours	≥16

### Advantages

Portability, rapid display of results and download of measurement data to the computer for radioactive contamination mapping

### Stage of Development. Suggestions for Commercialization

IRL8, TRL9  
Production sample. Sale of equipment. Upon request, the device is manufactured, set, and tested; staff training and maintenance during warranty period are provided; a technological framework for manufacturing model is created; the sample and serial production model are finalized; production process and solutions are optimized and customized to the key sales markets

### IPR Protection

IPR1

### Contact Information

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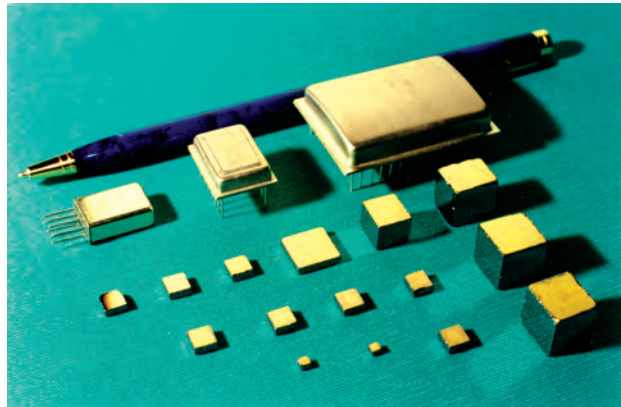
## X-RAY AND GAMMA RADIATION DETECTORS

### Areas of Application

The detectors are used for dosimetry and monitoring of X-ray and gamma radiation in nuclear energy, geology, ecology, medicine, and scholarly research

### Specification

Detector for measurement of gamma radiation exposure dose rate within a wide range (from 0.1  $\mu\text{Sv/h}$  to 10 Sv/h) with a high effectiveness of X-ray and gamma radiation counting ( $\sim 30,000$  pulses/ $\mu\text{Sv}$ );  
 Detector for measurement of high-energy gamma fields during emergency operation of nuclear power plant with a dose rate from 0.5 Sv/h to about 100 Sv/h, an analog sensitivity of  $\sim 2 \times 10^{-3}$  C/Sv, and a high resistance to radiation (up to  $10^5$  Sv);  
 Detector for radionuclide control and detection is used for spectrometry of X-ray and gamma radiation within the energy range from 5 keV to 2 MeV, with an energy resolution of 5% (662 keV); the device enables to qualitatively estimate the contribution of individual radionuclides



CdZnTe crystals and detectors



CdZnTe detectors

### Stage of Development. Suggestions for Commercialization

IRL6, TRL6  
 The products are manufactured and sold upon request

### Advantages

The sensors have no analogues in Ukraine; can operate at a room temperature

### IPR Protection

IPR1

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## TECHNOLOGY READINESS LEVEL (TRL) SCALE

Stage	TRL	Interpretation	Definition and Description
Invention	TRL1	Basic principles observed	Basic scholarly research is translated into potential new basic principles that can be used in new technologies
	TRL2	Technology concept formulated	Potential areas of application of basic (technological) principles, including the technological concept are identified. Basic manufacturing principles are elaborated and potential sales markets are identified. A small research team is established to assess the project feasibility
Concept validation	TRL3	First assessment of concept and technology effectiveness	Based on preliminary study, actual research is conducted to assess technical and market feasibility of the concept. This includes active R&D works at the lab and first negotiations with potential customers. The research team expands. Market feasibility is assessed
	TRL4	Prototype validation at lab	Basic technological components are integrated to assess early feasibility by testing in laboratory environment. Manufacture options are studied with basic manufacturing principles identified. Key markets are researched to study demand. The organization is ready to scale up, possible services are analyzed. Comprehensive marketing analysis is made
Prototyping and incubation	TRL5	Prototype testing in user environment	The system is tested in user environment with broader technological infrastructure involved. The actual use is tested and validated. Production-support works and pre-production tests are done in lab environment. Trial batches of prototypes enter the key markets. The organization starts activities to further distribute the prototypes and to enter the sales markets
Pilot production and demonstration	TRL6	Pre-production, including tests in user environment	The product and manufacturing technologies are completely ready for launch of a pilot line/pilot plant (low-scale manufacture). The product and manufacturing technologies are assessed and finalized. This may include additional R&D works. The early products and manufacturing technologies are tested in the key markets with simultaneous organization of manufacture (marketing research, logistics, production facilities, etc.)
	TRL7	Low-scale pilot production demonstrated	The product manufacture is fully operational at low rate. Actual commercial products are manufactured. The final products are verified in the key markets. The organizational component is completed (comprehensive marketing strategy, all components of manufacturing activities). The products are formally launched in test markets
Initial market introduction	TRL8	Manufacture fully tested, validated, and certified	The manufacturing flow charts, product final version, production organization, and marketing tools are completed. The full-scale manufacture has been launched. The final product is sold in majority of domestic and international markets
Market expansion	TRL9	Manufacture and products fully operational and competitive	The full-scale manufacture is sustainable, with the product gaining new markets. Minor modifications and improvements create new versions. The technology and product output are optimized through implementing innovative concepts on manufacturing process. The product is fully customized to the key markets

## INNOVATION READINESS LEVEL (IRL) SCALE

IRL	Innovation Readiness Level	Definition
IRL1	Inventor or team with a dream	The lowest level of readiness where the intention transforms into an idea of space system application or the space technology transforms into a business venture
IRL2	Paper studies produced	Once the basic ideas have been formulated, they are put down on paper in studies and analyses of business opportunities
IRL3	Experimental evidence of business opportunity	Active research and development are initiated, including analytical / laboratory studies to validate predictions regarding the market, the competition, and the technology
IRL4	Capability to implement limited-scope programs with project teams	Basic technological and business components have been developed to establish that they will work together; an initial business plan is available
IRL5	Capability to support project engineering development and design (no product, no revenues)	The basic technological and business components have been integrated with reasonably realistic supporting elements. The business plan is credible, but still needs to be validated against the final product characteristics
IRL6	Capability to support development and design with a market-driven business team (product, no revenues)	The representative prototype system has been tested in a relevant environment. The business team is still incomplete and the venture is not yet ready for commercialization. A full business plan including the market, the operational, the technological, and the financial aspects is available
IRL7	Capability to support limited production; full business team in place (product and limited revenues)	The business can run on a limited scale. The full team is in place
IRL8	Capability to advance to full production and distribution (product and revenues)	The technology has been proven to work and the venture structure has proven to be able to support growing market shares
IRL9	Fully articulated business with appropriate infrastructure and staffing (growing market share)	The offering incorporating the new technology has been used in operational conditions and the business is running with a growing market share

## Intellectual Property Rights Protection<sup>1</sup> Levels

IPR codes	Protection Level
IPR1	Technical solutions are know-how <sup>2</sup>
IPR2	Applications for copyright protection of IPR objects are expected to be or have been submitted
IPR3	The copyright protection of IPR objects as established by the applicable law of Ukraine has been obtained and is kept in force
IPR4	International industrial patent application(s) (according to the PCT system, etc.) has (have) been submitted. Application(s) for industrial patents has (have) been submitted in foreign country(ies) under national procedure
IPR5	The industrial patent(s) in foreign country(ies) has (have) been obtained and is/are kept in force

<sup>1</sup> The IPR protection measures are implemented by R&D institutions in accordance with the applicable legislation of Ukraine and the requirements of paragraphs 5, 8, and 9 of the Regulations for the use of intellectual property objects at the NAS of Ukraine as approved by Resolution of the Presidium of the NAS of Ukraine No.15 of January 16, 2008, on the Structural Units Responsible for Technology Transfer, Innovation Activities, and Intellectual Property (as revised)

<sup>2</sup> Know-how is technical, organizational, or commercial data obtained with the use of experience and upon trials of technology and its components, which are: closely held (not a part of general knowledge or available for public) on the date of license agreement; essential, i.e. important and useful for manufacture of products, manufacturing process, and/or provision of services; and elaborate i.e. detailed and complicated enough to verify their compliance with the criteria of being never-before-known and essential (Clause 1 of the Law of Ukraine on the State Regulation of Technology Transfer Activities)

Reference Book

THE NATIONAL ACADEMY OF THE SCIENCE OF UKRAINE

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R&D  
AND TECHNOLOGIES**

**THE NAS OF UKRAINE**

IN 11 SPECIAL ISSUES

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