



Electromagnetic Exposure on the Living Aquatic Ecosystems Behavior

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Abstract

An investigation into the motion activity of aquarium fishes *Carassius Auratus* was undertaken at the Laboratory for Electrophysics of Natural Ecosystems of the St. Petersburg State Polytechnic University. For this purpose, a new automatic video shooting technique was used, which, however, is still tentative and needs to be further improved. Nevertheless, there is an urgent need for some technique for detecting the physiological effect of the nonionizing electromagnetic radiation emitted by modern cellular communication apparatus on the human body. No reliable safety criteria for such apparatus have been established so far, and no device for neutralizing the effect of intense radiation on the human brain tissues has found wide use because they do not seem to be quite effective. With this in mind we undertook an experimental research into whether the Aires Neutralizer of Electromagnetic Abnormalities is efficient.

The spectral and fractal analysis of the pulsations of the motion activity (**MA**) was carried out. Evaluative data on the video shooting results were derived, including the *Hurst-exponent*, the *Fractal Brownian motion coefficient*, and the *Spectral dimension*. It was found out that there was a difference in how the **EMF** of a cellular phone operating in the 900/1800 MHz range influenced the animals in the two different situations:

- *Without the AIRES Neutralizer*: Suppressive influence of the cellular phone radiation was observed.
- *With the AIRES Neutralizer*: Protective effect was observed. The motion activity of fishes remained unchanged under a short-term exposure to the cellular phone radiation.

Key words: aquarium fishes; electromagnetic field; cellular phones; measuring systems; fractal dimension.

This Paper presented within
Living in Memory of Evsey Slutsky

Introduction

The living process of aquarium fishes *in-vivo* investigated by V.Alexandrov from 1980 to 2003, inclusive. He has applied the electrometric method to observe of fishes motional activity (MA). The natural electrokinetical potentials ΔF s generated by a complete organism (or group of specimen) in the process of its motion was measured. The biorhythms of behaviour, the amplitudes and level of electric signals in MA. A motional activity depression for *Cyprinidae* fishes has been detected during geomagnetic storms in laboratory environment. The use of *Fourier analysis* succeeded in the specific hour-range biorhythms detection, where partial or complete depression is observed during magnetic stimulation in solenoidal coil [1, 2]. But electrometric methods for fishes motional activity registration have several shortcomings:

- the changes natural background by systems of the indicator electrodes;
- the necessity of the systematical inventory of the diffusion ΔF s drift in time;
- the arising electric disturbances in measuring contours.

Therefore other methods for investigations were used. For the first time it became possible to find out instrumentally on an organismic level *in-vivo* and to show with the help of computer based video registering system origination of fish behavioural response on the influence of weak EMFs induction from 200 through 1000 nT with frequency from 1 through 10 Hz; as it is known, the change of behavioural physiology of an organism make signals about perception of the physical factor influence by a central nervous system [3, 4, 5]. In this paper a video-registration system to characterize motional activity of the fishes with an adequate, objective and non-invasive way is presented.

Methods

We have applied a simple installation to obtain the continuous videosignal from an aquarium with fishes (Fig.1, 2). The hardware includes a web-camera and a computer. The software is standard programs for video capturing and image processing. As a result of capturing and image conditioning we get the sequence of 1-bit (black-white) images. To derive a time series, that characterizes the motional activity of the fishes, from such a film, it was suggested follows: we subtract two neighbouring frames and count the number of on-pixels on this difference image. The more this number, the more the difference between two consecutive frames. Hence, this number characterizes the image change, it means, the motional activity at the given moment (Fig.2).



Fig. 1 Population of the *Carassius Auratus Japonicus*
Flabellicaudatus, Slutsky, 1985 goldfish

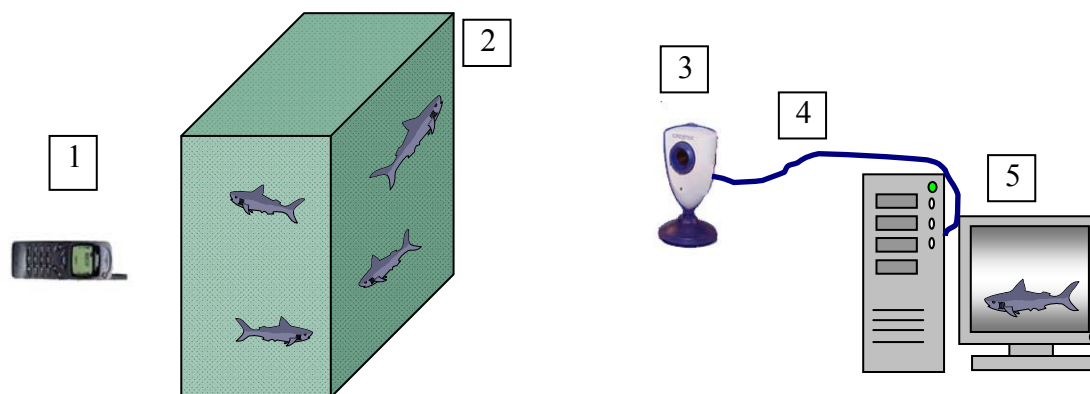


Fig. 2. Installation for registration of fishes motional activity.
1 – EMF source; 2 – aquarium with fishes; 3 – web-camera;
4 – USB-bus; 5 – computer.

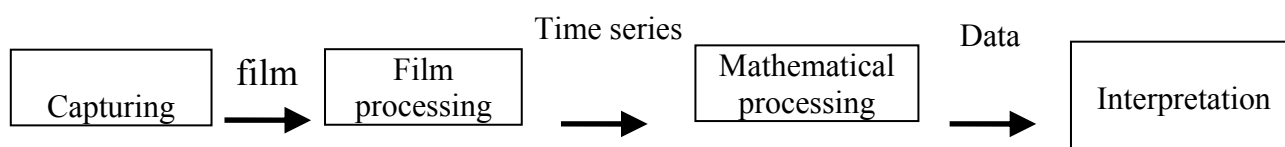


Fig. 3. Structure of method for fishes motional activity registration

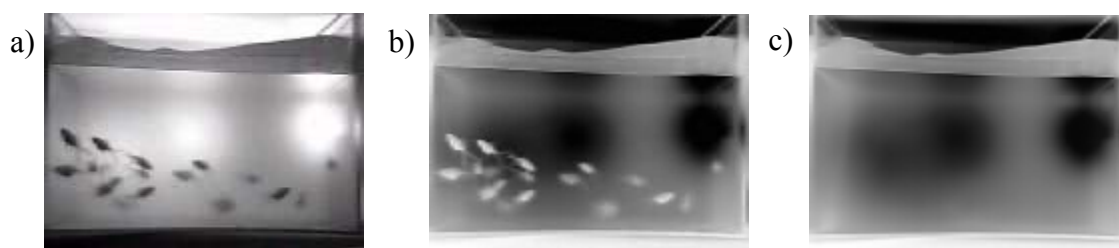


Fig. 4. Examples of frames on different stages of film processing:
a) Original film; b) after inverse; c) averaged frame.



Fig. 5. Subtract two consecutive frames:
a) и b) two consecutive frames after thresholding and filtering; c) difference frame.

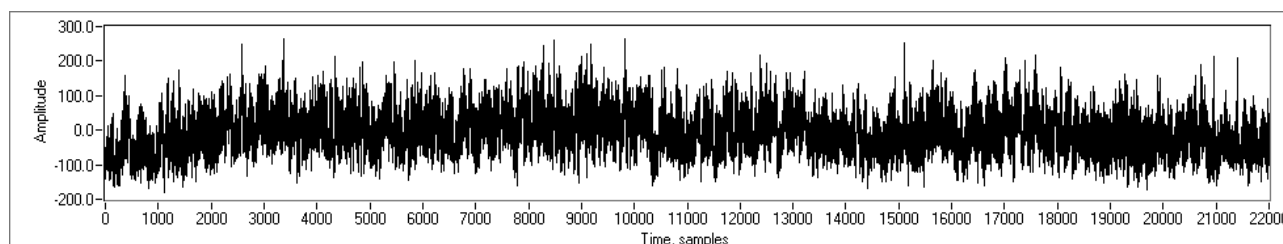


Fig. 6. The motional activity curve

The structure of the motional activity registration method is presented on Fig.3. On the first stage we record a sequence of aquarium images during the given time period (on Fig.3 - the block “Capturing”). As a result of this stage we have a video file (“film”) on the computer’s hard disk. The second stage is film processing to obtain characteristics of motional activity and other information about fishes behaviour (On Fig.3 - the block “Film processing”). The film processing includes the following sequence of operations:

- Preliminary conditioning (Fig. 4)
 - format conversion
 - frame cropping
 - inverse
 - intensity equalization
 - the average frame subtracting
- BW image deriving
 - thresholding
 - filtering
- the time series obtaining (Fig. 5)
 - subtracting of two consecutive frames
 - on-pixels counting

As a result we have a curve of motional activity - a time series, that characterizes the intensity of fishes motion at every time moment (Fig. 6).

On the third stage we make mathematical processing of the motional activity curve to obtain different characteristics of the fishes motional activity - spectral analysis to discover periodicity, statistical, fractal analysis (On Fig. 3 - the block “Time series processing”).

The goal of the forth stage is to make estimation, how much the measured motional activity characteristics deviate from the norm, i. e. is the fishes motional activity for the investigated time period anomalous or normal, high or low. This estimation must be based on the statistic data of observation (on Fig. 3 - block “Interpretation”).

To describe spatial distribution of fishes motion we construct “statistical diagrams of fishes situation”. Every such a diagram is a surface on a three-axial graph, where the coordinate plane XY corresponds to the plane of an aquarium image, and coordinate z of every point of the surface is equal to number of frames, where this point (with coordinates x,y) was “on”. In other words, the higher a point of this surface above aquarium image (frame) plane, the longer fishes were situated in this region of the frame during the investigated time period (Fig. 7).

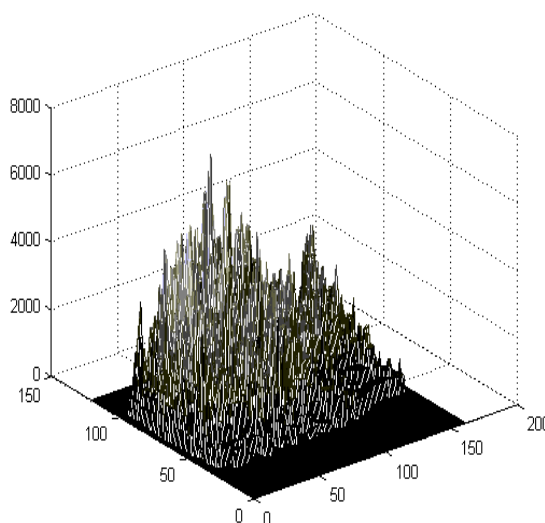


Fig. 7. Statistical diagram of fishes situation.

Measurements

At present we study the behavior physiology of a new variety population of the *Carassius Auratus Japonicus Flabellicaudatus*, Slutsky, 1985 goldfish [4,5](Fig.1). Under controlled (or monitored) experimental conditions (natural and artificial EMFs; natural and artificial barometric fluctuations; light/dark regime), protocoling (video recording) the motion activity, primary and secondary orientation, searching, feeding, defensive and social behavior is to be performed. The ethograms describing the species – typical behavioral patterns under normal conditions and at the EMF-induced syndrome will be constructed. As the main background variable. The amplitude-frequency characteristic of the geomagnetic and the experimental (artificial) extremely low EMFs and high EMFs were be measured (Fig. 8, 9). The equipment to be used includes a generator of the EMFs in wide amplitude-frequency range (used also for a compensation of the natural geomagnetic field; error bellow 1%), original magneto-metric and baro-metric instruments constructed by Russian specialists and certified in the Mendeleev's Research Institute of Metrology (St.Petersburg), IBM PC with original software (3 units), Cellular mobile phones NOKIA 3110 (2 units), aquarium units for fish maintenance and for performing the experiments, pH-meters, thermometric instruments et al (Fig. 10, 11). Therefore we have new equipment for investigations of the influence a cellular phone radiation at biological objects: AIRES Neutralizer [10,11]. This graphic constructions were called matrix applicators and in 2001 were officially certified as medical devices (TC 9444-001-48971233-2001). Primary dates of measure ΔEFs near the cellular phones are presented (Fig. 10, 11, 12).



Fig. 8. Measuring **EMF** by magneto-metric instruments in aquarium area

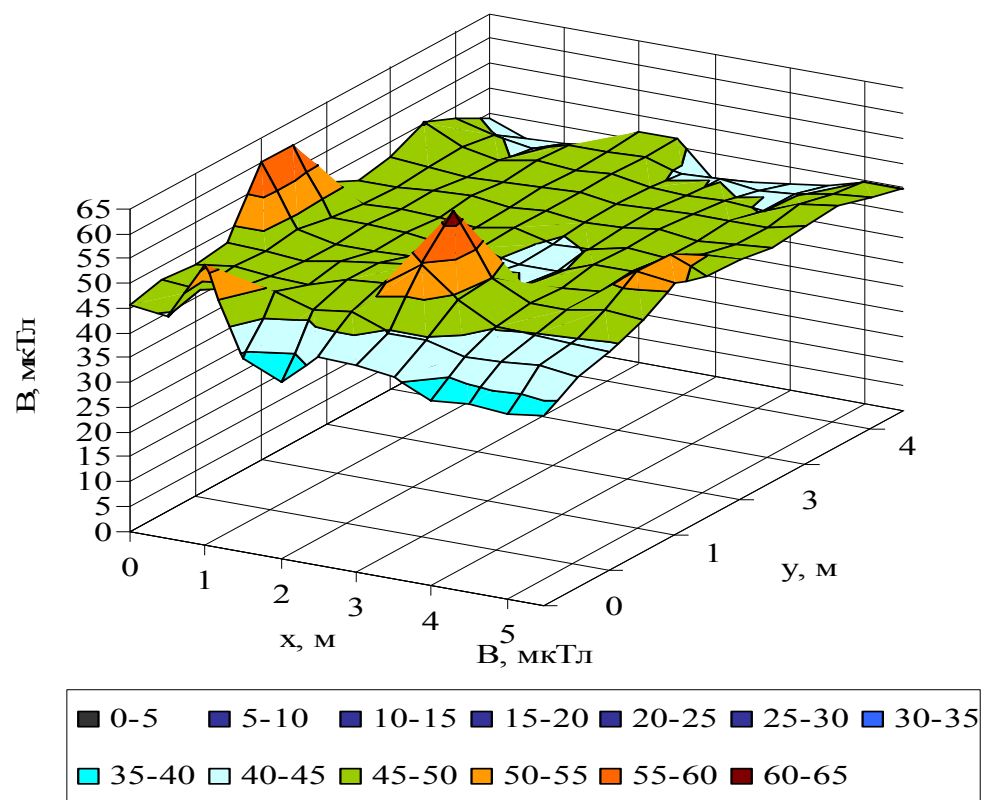


Fig. 9. Background oscillations of a magnetic field in laboratory



Fig. 10 AIRES Neutralizer place on mobile phone NOKIA 3110.

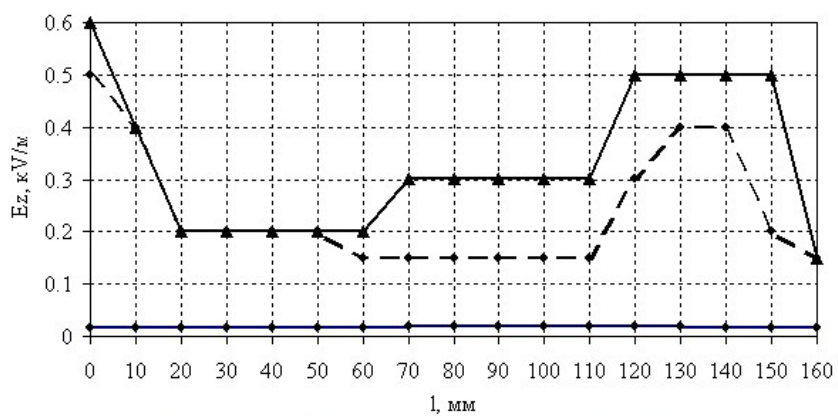
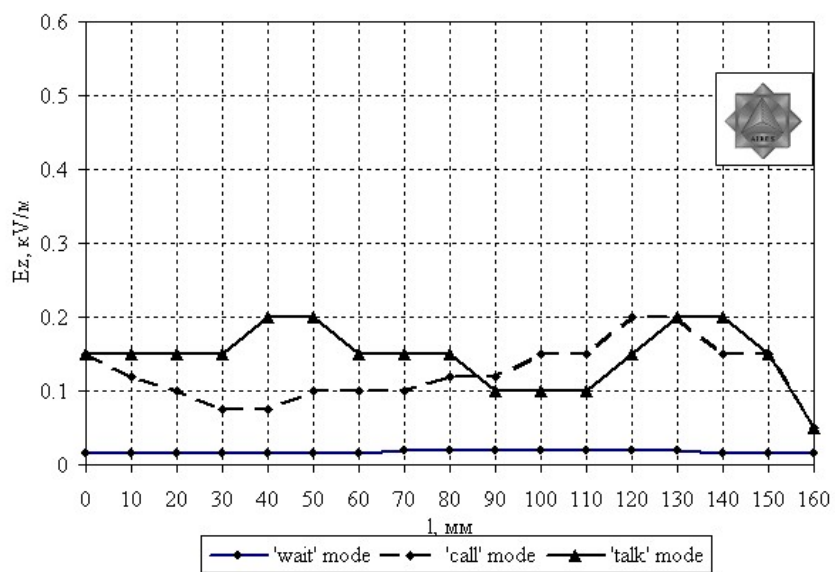
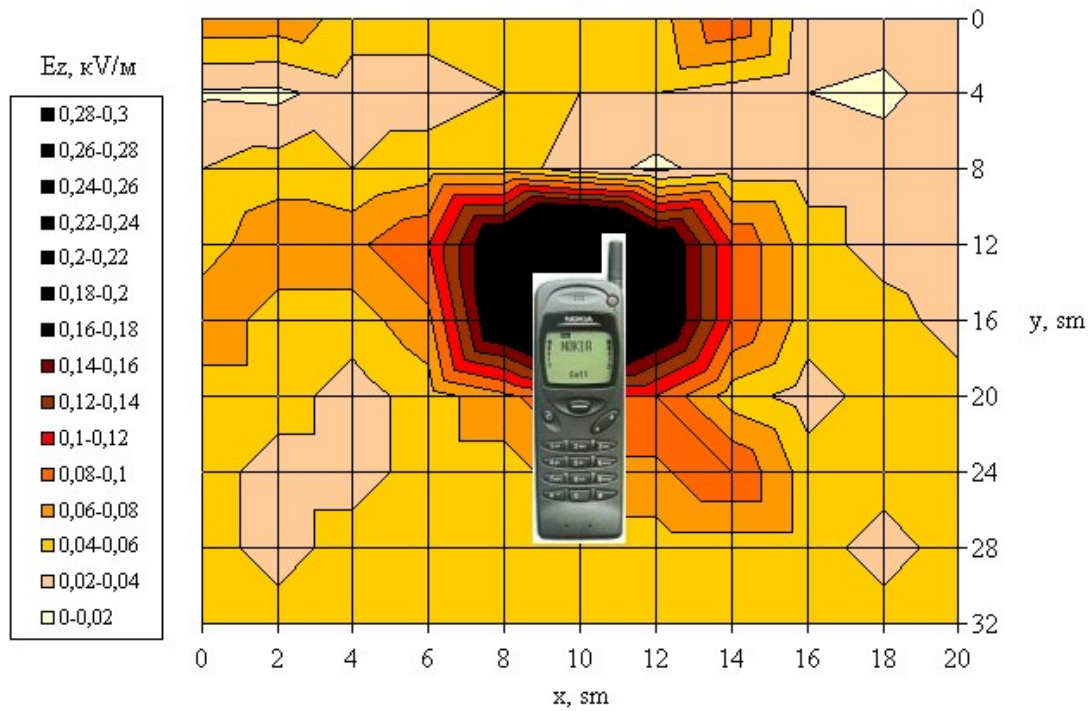


Fig. 11. Electric field along of mobile phone NOKIA 3110 With the AIRES Neutralizer (up) and Without the AIRES Neutralizer (down).

Electric field of phone NOKIA 3110 in "call" mode



Magnetic field of phone NOKIA 3110 in "call" mode

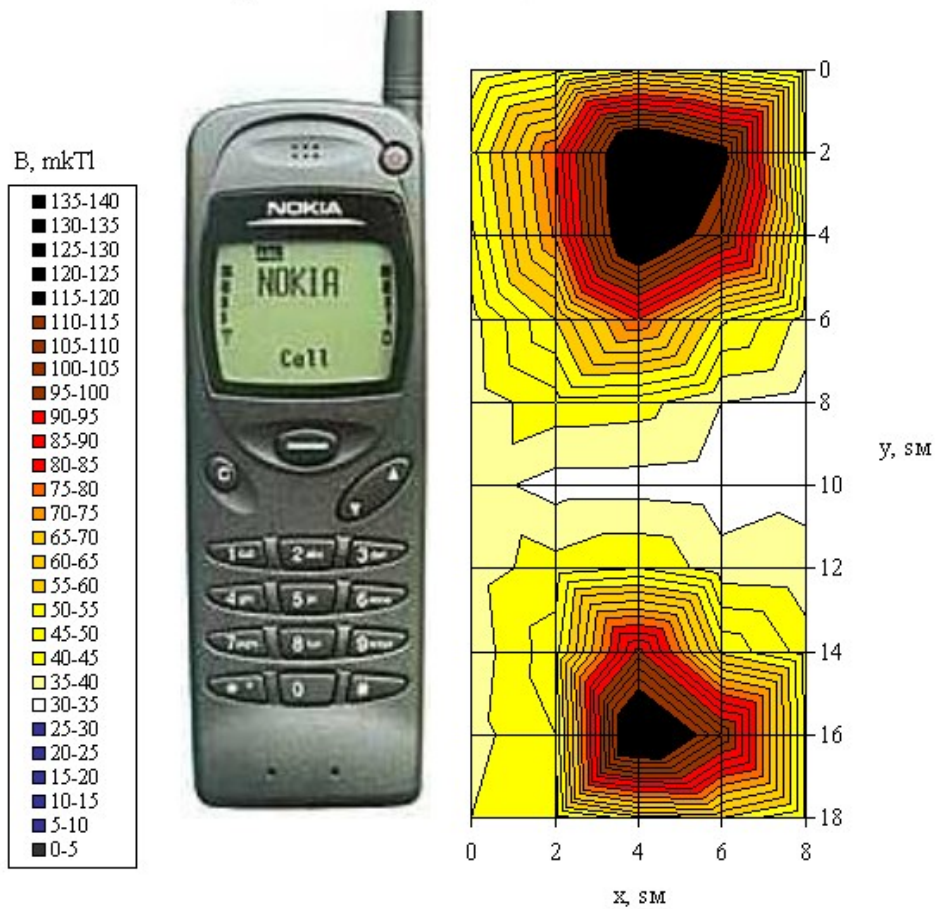


Fig.12. Electromagnetic field of mobile phone NOKIA 3110 in "call" mode.

Results

A number of films with fishes has been shot and analyzed using the suggested method. We have selected films containing no disturbances that, in our opinion, may cause distortion in resulting time series. These are 3 films with duration 40 minutes, 1 hour, 73 minutes respectively. The frame rate was used is 5 frame per second. It was discovered, that these time series have 1/f-spectrum and reveal self-affinity (Fig.13). It means that they have fractal properties [6] and can be described in terms of fractal theory. Fractal analysis is a widely used tool for describing and modelling of dynamical behaviour of multiple natural processes [7,9], particularly, to estimate the state of biological objects [10,11,12]. Our assumption is, that the most adequate feature of such a time series associated with motional activity is fractal dimension and related values, such as Hurst-exponent [7], fractal Brownian motion coefficient and spectral dimension [8].

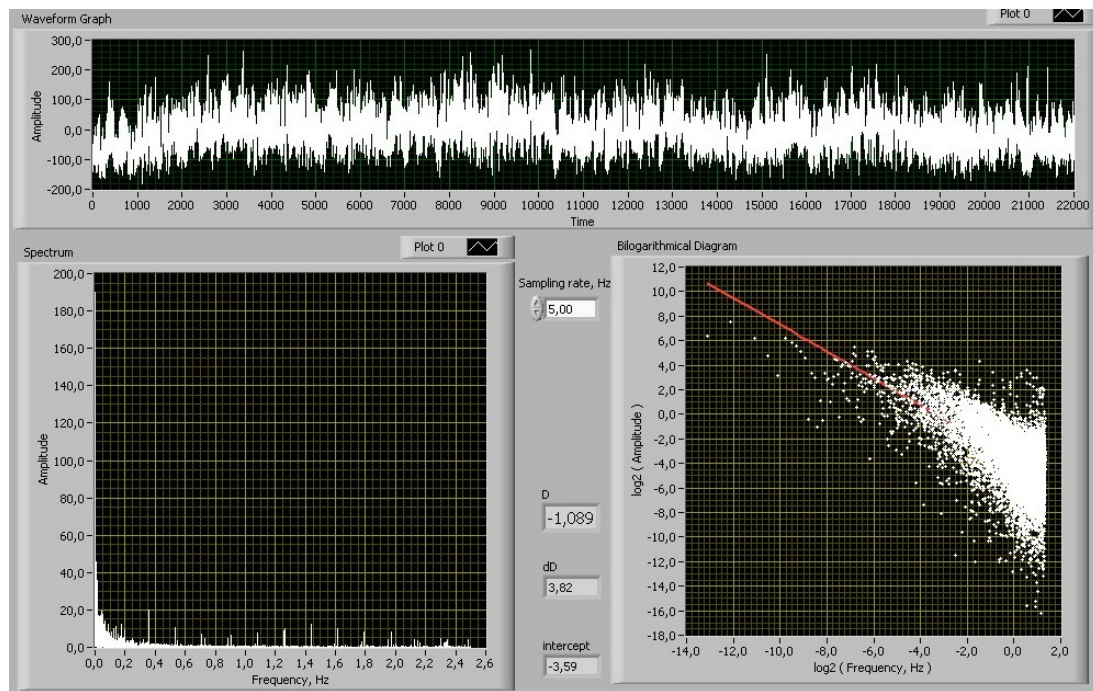


Fig.13. Spectrum of fishes motional activity curve in bilogarithmic scale.

The fractal features for corresponding time series were accounted (Tabl. 1). We suppose, that these values match to the motional activity of the fishes in the normal state.

Tabl.1. Fractal features of the time series of the fishes motional activity.

Film date	Hurst-exponent	Fractal Brownian motion coefficient	Spectral dimension
08.01.2003	0,87	0,14	1,10
09.01.2003	0,87	0,14	1,16
11.01.2003	0,85	0,12	1,00

Short-term exposure of fishes to the radiation emitted by a cellular phone operating in different modes lasted for three minutes (in more than 100 experiments), and the long-term for between one hour and one day (in 14 experiments). The spectral and fractal analysis of the pulsations of the motion activity was carried out. Evaluative data on the video shooting results were derived, including the *Hurst-exponent*, the *Fractal Brownian motion coefficient*, and the *Spectral dimension*. Also, statistical diagrams of the density of the fishes distribution in the aquarium were compiled and spectral energetic zones in the distribution $G(f) \sim f^n$ characterizing the behavior of fishes were revealed.

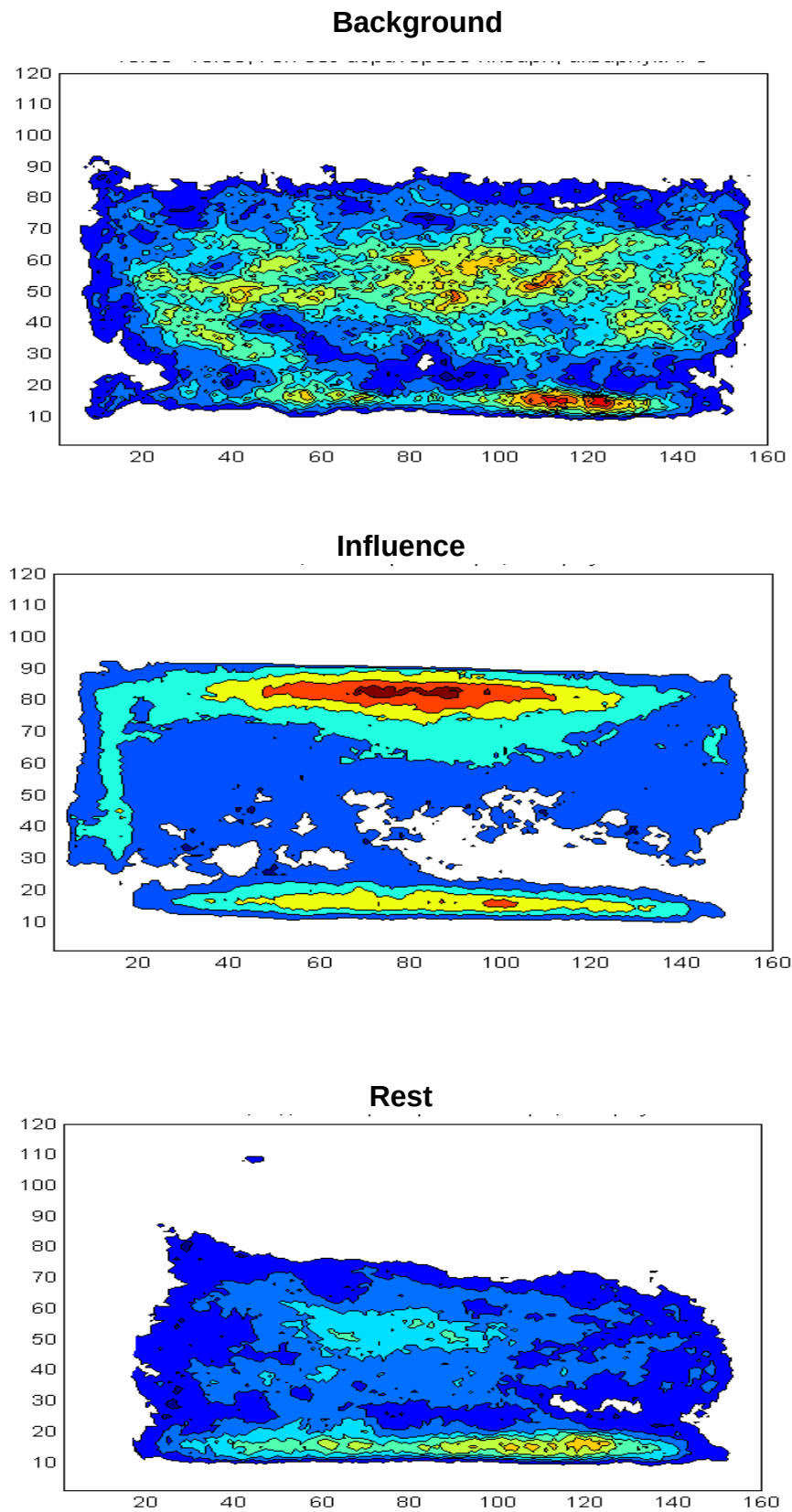


Fig. 14. Statistical diagram of fishes situation

It was found out that there was a difference in how the **EMF** of a cellular phone operating in the 900/1800 MHz range influenced the animals in the two different situations:

- *Without* the Aires Neutralizer: Suppressive influence of the cellular phone radiation was observed.
- *With* the Aires Neutralizer: Protective effect was observed. The motion activity of fishes remained unchanged under a short-term exposure to the cellular phone radiation.

For example we are presented the statistical diagrams of fishes situation: background (before action of cellular phone), influence (period of cellular phone disturbance of background) and rest (the source of **EMFs** change is absent).

Conclusions

The motional activity video-registration system was putted into operation. We suggested a method of image processing to quantify motional activity of the fishes. The first measured data shows, that corresponding time series reveal fractal properties. The preliminary results of fractal analysis are given. In evaluation period we collect statistical data and try to find features to quantify different aspects of motional behaviour of fishes. Then we are intending to use this method to investigate the influence of EMFs on the motional activity of the fishes.

To continue the research, support and new equipment are needed.

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