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ECOPHYSICS AND EDUCATION

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Abstract. *Environmental problems arise from an interaction of man with nature. Environmental physics uses a number of sub-disciplines of physics in order to solve this problem. This in turn necessitates the study of various aspects of the man-environment interaction through educational programs. In this paper, we discuss the motives for teaching environmental physics and present some ideas of how to improve the position of this subject in the educational system in Serbia. The role of specific seminars in this field is emphasized.*

Key words: *environmental physics, education*

INTRODUCTION

Life in harmony with nature, an ideal of Far Eastern nations, was created on the basis of high respect for powerful natural forces, as well as for searching pleasure and beauty in such harmony. However, the path to industrialization was marked by the increasing attempt of (young) Western nations to take control over nature. On this path, mountains were moved, rivers were dammed, valleys were partitioned, and the face of Earth was changed. Inconceivable treasures were created, life became easier, and a number of illnesses and adversities were defeated. However, it has now become clear that the centuries-long tradition of living apart from nature is a price one has to pay. After the industrial revolution, the explosion of population occurred. Now, the biggest part of the wealth acquired during the industrial revolution is needed in order to feed billions of people. Energy resources have to meet the needs of the population. In the fight and race for energy, we must not forget that using renewable kinds of energy are meant to restore the slightly lost balance with nature rather than violating it even further.

Physics plays an enormous role in understanding the environment. Social and political problems of global warming and depletion of the ozone layer, due to the effects of pollution and exploitation of energy sources, demand understanding the fundamentals of physics [1]. The capability of modeling and, therefore, forecasting weather conditions and climate changes requires an understanding of physical processes. Environmental

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physics is thus concerned with the application of principles of physics to the human activity induced problems in nature and its surroundings. It plays a central role in the studying, observing and, above all, understanding our world and the influence of the human race on it at both the global and local levels.

THE RELATIONSHIP BETWEEN PHYSICS AND ECOLOGY

The word "ecology" was first used by Heckel, a biologist, in 1866, in a text entitled "General Morphology" in order to refer to a discipline concerned with the influences generated between the living creatures and the environment. Ecology, as a new and as yet non-established scientific discipline was confronted from its beginnings with huge methodological problems. As it originally belonged to the group of biological sciences, much time was spent in an effort to adopt the standard research methods used in biology, such as description and classification. Consequently, an ecosystem was identified with the organism, while rivers, lakes or woods were identified as entities which had to be described first and, on the basis of their behavior, to be further understood and predicted.

At the beginning of the 20^{th} century, there were no ecology scientists who believed that complex ecosystem characteristics could be found from analyses of their elements plants, animals, and microorganisms.

Huge revelations in physics, which took place in the previous century, have led to a progress in the general methodology and philosophy of science. In the second half of the 20^{th} century, this progress led to the understanding that unless the methods similar to the ones used in physics and the modeling processes for the living environment are used, no progress in ecology will ever occur.

Trying to avoid scientific methods in ecology, on the other hand, presents a real risk. There is a huge difference between ecologists-professionals, and ecologists-activists. For the later, ecology is an ideological system, a kind of anti-science. So construed an ecology discards the use of mathematics, for example. However, scientific methodology needs to be applied in ecology, as this is the only way to solve problems properly. The use of mathematics, computer simulation and sophisticated statistical methods is nowadays increasing in everyday scientific practice.

Essentially, ecology has an interdisciplinary character. Biology, chemistry, applied mathematics, geology, oceanography, and physics are at the core of the disciplines concerned with the environment. Among them, physics plays a huge role, both directly (through projects related to energy production, for example) and indirectly (through fundamental research and education of staff responsible for a proper "rule" over the environment).

What we term "the environment" is the product of the million-year-evolution of life in nature together with various biochemical processes and matter and energy flow. Given that a great part of physics is dedicated to research into energy and its transformation, as well as that energy has a central place in all environment aspects, it is obvious that there are very deep and essential connections between physics and ecology. For example, climate shows us how the sun's energy affects the atmosphere, the ocean movement, and the distribution of energy to Earth. Man's enormous influence on the environment in which he lives results from his energy needs, namely, from energy production and/or adaptation of those energy forms that are suitable for use.

For many people, the concept of associating physics and ecology is impossible. There is, however, a simple argument in favour of this relatedness. All disturbances in the environment are to some extent due to some discovery in physics (the most obvious example is the discovery in nuclear physics). However, there are some different, positive relations between physics and ecology.

As regards the above observation, we have to note that there are different concepts of the term "ecology." Ordinarily, ecology is conceived of as an independent science, mostly related to biological sciences. Related to this are those concepts of ecology that see it as a science dealing with the technical elements of environmental pollution induced by the anthropogenic (human) influence on the environment, as well as creation of measures to reduce this influence. In the modern aspect of the term, ecology is viewed as a science which has to unify all scientific knowledge about the biosphere and offer predictions of the future events. This prognostic function of ecology, however, has to be fulfilled only if rooted in the basic principles of nature, i.e. the natural laws governing its functioning. What are these laws? Biosphere can be described as a wide, open thermodynamic system. Movement of air masses in the atmosphere and sea streams is a good example of the planet's dissipative structure. Actually, Earth is a thermodynamically wide-open system into which the sun pumps its energy all the time. In the further process of transformation and photosynthesis, for example, this energy converts from one form into the other. Heat energy, which consistently comes from the sun, is, on the other hand, balanced by the radiation of Earth.

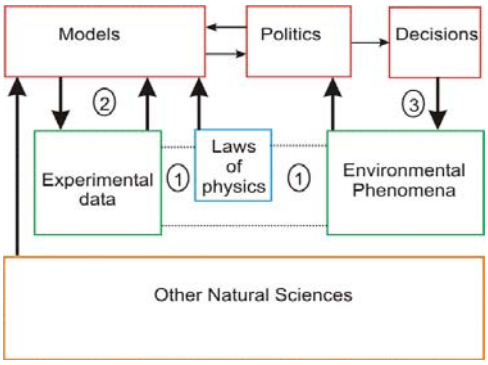

Fig. 1. Scientific areas dealing with environmental physics (eco-physics). A traditional academic scientist studies a phenomenon under controlled conditions and finds the laws of physics (loop 1), while an environmental physicist needs much knowledge of physics for modeling the human impact on the environment. Models are tested through experiments and data (loop 2). Finally, political decisions can be made which alter man-induced environmental phenomena (loop 3).

Physics provides a basis for understanding a dynamic interaction between the atmosphere and oceans, and for studying short-term meteorological and long-term climate changes. Understanding these kinds of processes is essential to ecology for the following reasons: detection of urban air pollution, acid rain phenomena, and monitoring natural risks such as tornadoes and floods. In the process of understanding environmental complexity, as well as of recognition of problems, physics has to be combined with chemistry, geology, atmosphere- and oceans-related sciences, and biology.

As we speak about physicists dealing with the environmental issues, the American Academy of Sciences has recognized three key areas which physicists have to deal with for the wellbeing of mankind [2]:

– oceans-atmosphere system;
– monitoring of the living environment and indicating how its quality can be upgraded; and
– energy production.

The Oceans-Atmosphere System

At the end of the previous century, the better understanding of the environment and the improvement in our prediction capacity have now made it possible to make early notification of pollution dangers. This progress is the result of combination of theoretical modeling, computer simulation and direct measuring.

Until the eighties of the previous century, the atmosphere-related sciences were focused on the theory and practice of weather reports made on a 6-10 days scale. Weather forecasts were based on the studies of the propagation changes in air masses with fluid dynamics Navier–Stokes equation analyses. As for oceans, the emphasis is on the understanding of the physical processes governing heat and mass transfer caused by sea streams (like Gulf stream) and circulation between oceans. It seems clear that changes in the atmosphere are independent of the changes in oceans and vice versa, even on the time scale of less than a decade.

Nowadays, it has been noticed that oceans and the atmosphere are mutually related, even on a much shorter time scale. It is the result of the understanding of the *El Niño*[1] phenomenon. A series of positive and negative back influences between oceans and the atmosphere lead to the phenomenon, namely, one oscillation on a huge scale is responsible for climate instability in the Pacific region. The understanding of this phenomenon, which is the result of the mutual fluid dynamics of oceans and the atmosphere, allows for predictions of climate changes. This predictability is demonstrated not only on a 6-10 days scale but on a six month to one-two years scale as well, which is the scale on which the El Niño phenomenon occurs as the result of the oceans-atmosphere instability connections. Upon successful explanation of the above phenomena, it was shown that huge monsoons represent the same time scale related oceans-atmosphere phenomena as well, and that their evolution depends on a mutual dynamics and thermodynamics of oceans-atmosphere.

Monitoring Changes in the Living Environment

The problems pertaining to the treatment of the living environment demand a much better organization of human activity in order that its negative influence on nature could be reduced. This kind of problem occurs much more frequently due to the growing human population on Earth, as well as the technological progress of the human population.

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[1] *El Niño* was first noticed by fishermen on the South American coast, as an annual appearance of unusually hot water in the Pacific. *El Niño* means "a little boy" or a baptized child (Christ) in Spanish. Using this name has its origin in the fact that the phenomenon occurs at Christmas. There is also a phenomenon termed *La Niña,* "a little girl," which is characterized by unusually cold water. Both phenomena have huge influences on the weather in the entire planet Earth.

Mankind is, however, more successful at solving this problem because of the general scientific progress. Actually, similar problems occur in a wide range of areas, from radon or organic source pollution of a room, through atmospheric pollution of the neighborhood of an industrial plant, to global changes in the atmosphere caused by CFC or nitrogen oxides.

The finding that destruction of the stratospheric ozone is due to the compounds of the CFC type is a classic example of how science (in this case chemistry and physics) contributes to the understanding of how human behaviour changes the living environment.

Global warming is partly the result of the carbon cycle change in Earth, triggered by the combustion of fossil fuels. The growing rate of carbon dioxide leads to "the green house gases", the concentration of which increases with a change in the global hydrological cycle. There are numerous scientific disciplines involved in the study of global warming phenomena and the monitoring of climate changes. Geophysical fluid dynamics is necessary for understanding the basic climate changes. At the same time, chemical and biochemical cycles are active partners in the dynamics and thermodynamics of climate systems.

Effective management of human interaction with nature, i.e., environment, demands a parallel progress in some fields:

- understanding the function of the living environment by excluding the human factors;
- understanding of how the human impact changes the living environment; and
- understanding to what extent this impact can be reduced (for example, by substituting of one kind of energy with another).

Energy Production

Nowadays, the interest is growing in the so-called renewable energy sources, such as the energy generated from the sun, wind, tides, and temperature differences in oceans, as well as geothermal and biomass energy. This interest originates from ecological reasons, not from the rising prices of fossil fuels, as there are still enough fuels at relatively low prices. The interest is caused by caring for the environment in which we live. It is believed that combustion of fossil fuels greatly affects the occurrence of acid rain and global warming. We cannot neglect the fact that powerful countries (mainly the USA) show an increased interest in renewable energy sources, as these could reduce dependence on foreign energy sources. Our country also proclaimed a policy of relying mainly on its own resources and of development of methods for exploitation of available domestic energy sources. Due to various reasons, we still depend on foreign energy supplies. Participation of imported energy consumption in the former Yugoslavia was 16.6%, in 1965, 29.7% in 1970, 32% in 1975, and 38.8% in 1980 [3].

PLANNED ACTIVITIES OF PHYSICISTS IN THE PROTECTION OF THE LIVING ENVIRONMENT

A great attention in the world is paid to the role of physics in the living environment preservation. For example, in the almost 200-page-long document *Physics in a New Era: An Overview* [2] by the American Academy of Sciences, an important role in environmental preservation was given to physics. A great number of Internet sites in America are dedicated to various aspects of this problem. This is not accidental, as America is the country whose "contribution" to disturbances in the environment is estimated as greatest.

In 1990, the British *Institute of Physics* formed a section for environmental physics comprising some 500 members. Its purpose is the application of physics to the environment changed by the human activity. The work of the institute runs through a lot of activity such as: one-day meetings, visits to centers which deal with environmental preservation, and organization of frequent interdisciplinary conferences (4-5 times per year). The section has a special subcommittee for education the main concern of which is development of environmental physics course programs in schools. There is a *Herald* in which activity reports are published two–three times a year. In 2001, this section prepared *Energy Technologies of the Future* report [4], in which the role of physics and physicists is emphasized, especially in the development of new technologies in the field of energy.

New magazines have been established for publishing scientific papers about environmental physics. For example, the leading European magazine in the area of physics education, *European Journal of Physics,* invited in its September 2003 issue all interested parties to submit scientific papers on methods used to transfer knowledge of environmental physics to students [5].

The European Physics Society has its own section whose mission is to unite all physicists in Europe interested in environmental physics and its connection with related scientific disciplines.

In Russia, there is a magazine called *Ecology and Life* in which scientific papers on different aspects of ecology are published.

In Serbia, it seems that its future development indicates that a rise in investment in ecology is to be expected. There are official inspection agencies and advisory services in the various regions and municipalities in the country, as well as specialized institutions dealing with environmental problems. There are university schools and departments with the word "ecology" in their logos. As for the role of physicists in environmental protection, it has to be emphasized that the main issue is opening new job positions that would allow physicists to use their specific knowledge and yet be able to contribute to various aspects of environmental protection.

ECOLOGY AND EDUCATION

In the eighties of the 20th century, marked by the discovery of the ozone layer hole and the growing interest in acid rain effects, the term "environment" or "green chemistry" was developed and adopted by many university chemistry departments as central part of undergraduate studies. Departments of physics were, however, slower in recognizing the need for and showing interest in environmental studies. Nowadays, most departments of physics have at least one undergraduate final, which involves the physical dimension of the environment. There are numerous recognized diplomas in the world in environmental physics at the level of undergraduate, Master and Ph.D. studies. Various aspects of environmental physics have been integrated into school programs, encouraging younger generations of students to understand and study physics. However, "studying" environmental physics cannot be understood as simply "filling up" physics classes with examples of how the laws of physics pertain to the living environment. Instead, the main purpose of studying environmental physics should be description of environmental problems and demonstration of how, with the help of physics, these problems can be examined and/or measured.

Students have to understand that physics is essential to the understanding of the planet Earth and its further development. Only if we teach them this, the next generation of students will be in a position to respond to and control the human challenge and its ever-growing influence on the delicate ecological balance.

All university or institute workers should have the responsibility of contributing to increased research in the area of environmental physics. As we expect industry to develop to a relatively significant degree in the forthcoming period, and given our current political position, we should not be surprised if industry gets relatively "dirty." To solve this problem, it would be wise to timely incorporate into our educational system such programs that would raise an ecological sense to the overall development. It is in particular important that such programs be aimed at the student population, as they are the future of our society. It is, however, highly important that an ecological sense be developed as early as possible, starting from the preschool period. In America, for example, even children in daycare centers learn what is recycling. As a consequence, it is often children who warn their parents how to sort out waste at home, i.e. one which is recyclable and one which is not. The same applies to energy. It is known that the development of a child in the preschool period is marked by acquiring exactly those habits that will guide his behaviour throughout life.

ELEMENTS OF ENVIRONMENTAL PHYSICS IN CURRICULA

At present, many aspects of ecology are studied within biology and chemistry in elementary and secondary schools. The ongoing reform of the educational system in our country gives us the opportunity to introduce entirely new school subjects or to adjust the existing physics syllabi by integrating some ecological contents into them. It has to be done for practical reasons, as well as for the purpose of developing a long-term interest of the society in environmental protection.

The number of university schools and departments in Serbia is increasing which offer ecology-related courses. The University of Niš Faculty of Occupational Safety has an entire department for protection of the living environment. The Faculty also has a strong department for Noise and Vibration Protection. At the University of Niš Faculty of Sciences (PMF), there is a department for Biology with Ecology. The situation is similar at other Serbian universities. At the University of Belgrade Faculty of Physics, one of the departments offers the course Physics of Ecology course, while at the Niš PMF, the Physics Department offers the course Energetic and Physical Sources of Damage. Various aspects of environmental physics are constitutive parts of master and doctoral degree curricula.

Although no undergraduate courses dealing with ecology directly are offered at physics departments, it should be clear that those interested in environmental physics related professions would benefit most if completing the undergraduate program in physics. Through this program, one has the opportunity to learn, for example, fluid dynamics (highly relevant to prediction of changes in meteorology) or kinetic theory (useful for pollutant dispersion analyses).

REFORM OF THE EDUCATIONAL SYSTEM AND ECOPHYSICS

With changes in the educational system in Serbia, the need has been born for updating educational process in physics and other natural sciences. Development of an ecological sense and environmental protection by using new scientific knowledge and modern techniques in physics constitutes the basis for a quality education. This can be reached in two ways: first, by introducing core and elective courses in physics and, second, by integrating ecology-related contents into curricula and physics syllabi at all educational levels. In this way, we can achieve a sufficient level of educational quality and develop among the population of all educational levels a positive attitude towards responsible behaviour to the local and global environment.

A very important product of the recently undertaken educational reform in our country is the establishment of accredited seminars on the part of the Ministry of Education and Sport. Accreditation has the role of establishing order in programs aimed at teacher training, which have been offered from a variety of sources. One of the most important programs on natural sciences (highly relevant for the issue under discussion here) is the seminar Eco Physics. This accredited program is based on the teamwork of teachers and students and, especially, students organized in groups, who examine specific problems and attend physics and ecology courses for the purpose of upgrading individual and collective responsibility to the environment [6]. The authors of the program are D. Belić (Faculty of Physics, University of Belgrade), M. Terzić (Department of Physics, University of Novi Sad), D. Markušev (Institute of Physics, Belgrade), Lj. Nešić (Department of Physics, faculty of Sciences, University of Niš), D. Milićević and I. Zornić (Kruševac High School). The program was realized in four cycles of three days each in the school year 2003-04 at Kruševac High School and Department of Physics, PMF, University of Niš. More than a hundred (130) students participated in each of the cycles, 65% of whom were biologists, 30% chemists, and 5% first-to-fourth grade elementary school teachers. Detailed information about this seminar can be found at: http:/www.dfs.org.yu, link Ekofizika.

Basics of the Seminar Eco Physics

The main goal of the program was:

- Professional training of teachers of physics, chemistry, and biology in elementary and secondary schools, as well as first-to-fourth grade elementary school teachers, and introducing them to contents and teaching of environmental physics in our country and in the world;
- Methodological and chronological approach to environmental physics development and its connection with and integration into physics course units constituting core or elective syllabi and activities; and
- Through active participation in interactive seminar lectures and through direct participation in active learning workshops, educational processes should be updated, with an emphasis on the applicative aspect of modern physics and its influence on quality, control and protection of the environment.

Realization of the Seminar

Each of the four cycles was generally divided into (1) specialized lectures; (2) workshops; and (3) round tables. The purpose of the specialized lectures was to give theoretical

and competent information on the development of ecological studies in our country and worldwide, as well as to point to the importance of lectures in physics and other natural sciences (chemistry, biology) studied in elementary and secondary schools. A special emphasis was given to introducing various scientific methods used in environmental protection.

Having in mind the unenviable condition of Serbian schools today (outdated equipment, unavailability of modern ways of communication), this kind of seminar, in particular the specialized lectures track, proved essential. The following authors give their contribution in presenting various topics, listed below by cycles:

Cycle I: D. Belić, Physics and Ecology – The role of physics in environmental protection; Lj. Nešić, Ecological contents in physics courses; D. Markušev, Photo acoustic spectroscopy physical bases; M. Popović, Eco prognosis; M. Terzić, Measurement in physics, units and dimensions, limits of detection; M. Tasić, Atmospheric aerosols and their role in environment protection.

Cycle II: D. Belić, Pollution, protection and purification of the air; Lj. Nešić, Internet in ecophysics education, long distance learning; D. Markušev, Using of photo acoustic in pollutant detection, possibilities and limits; Dj. Bek-Uzarov, Physics method of detecting human and environmental contamination; M. Tasić, Physical and chemical characterization of atmospheric aerosols; M. Terzić, Radioactivity and its measurement.

Cycle III: D. Markušev, Noise and sound pollution first part – Sound – physical basics; Lj. Nešić, Ecological resources on the internet, their contrivance and application; D. Belić, Global effect of pollution, green house effect, acid rain, ozone holes; Dj. Bek-Uzarov, Error counting elements and spineless of measurement; M. Tasić, PM_{10} i $PM_{2.5}$ particles and their influence on health; M. Terzić, Laser using in human environmental protection;

Cycle IV: D. Belić, Solving of ecological problems from thermal plant exploitation "Nikola Tesla" in Obrenovac; Lj. Nešić, Creating of Eco – Web presentations and their role; D. Markušev, Noise and sound pollution second part – protection from noise; S. Mijović, Education in environmental science through eco system monitoring example of the Skadar lake; M. Tasić, Air quality in urban environment; M. Terzić, Electro magnetic field in living and working environment.

The purpose of the workshops was teacher training, i.e., the methods of organizing ecology classes both in the classroom and outdoors. All attendants of the seminars were divided into groups-classes, each of which gave four sub-classes. Their assignment was to individually study the given material and discuss it.

The workshops were adjusted to classes outside the classrooms. They consisted of three parts: (1) introducing the workshop theme and objectives (for e.g. noise and noise pollution); (2) practical classes outside the classroom (for e.g. the number of vehicles detected on a heavy traffic crossroads within a defined period of time); (3) acquisition of data and discussion (model making, drawing charts and calculating average noise levels).

The purpose of the round tables was promotion of discussion on important issues related to correctly implementing ecology classes, their introduction into curricula and syllabi, as well as accessibility of the literature and basic data on any kind of environmental pollution in our country.

The topics discussed at round tables are listed below by cycles:

Cycle I: Round table *Practical issue of eco physics course realization – plans and programs*; Round table *Accessibility, researching and arranging eco data*;

Cycle II: Round table *Meaning and influence of the correct specialized eco education 1 and 2, advantages and consequence*;

Cycle III: Round table *Development of local eco centers and their role*; Round table *Involving international systems of global protection, advantages and faults*; and

Cycle IV: Round table *Physics and social sciences – eco interaction 1*; Round table *Physics and natural sciences – eco interaction 2*.

General Conclusion of the Seminar

The specialized lectures track raised a great interest and proved highly justified. Attending the specialized lectures demanded the knowledge of at least the fundamentals of physics and other natural sciences and provided each participant with the opportunity to get to relevant information about current ecology-related activities both in the country and worldwide. Transfer of the role from "performer–participant" to "teacher–student" had as the primary goal to encourage teachers to take an active part in future classes, rather than being "passive guides".

As for the workshops, some resistance was initially exhibited to the workshops of "active learning" program type. The opinion could be heard that this kind of work is inappropriate in teaching natural sciences and, therefore, ecology that relies on them. The source of criticism expressed by some participants was their suspicion as to whether children of low elementary grades are capable of creative development and active learning on their own, as this kind of learning bears a real risk of retaining absolutely wrong conclusions.

Further, the workshops demonstrated that group work and discussion of the results is an acceptable kind of work but only if the teacher retains his/her active role, i.e., the one who tutors, corrects and verifies conclusions reached in discussions. The way of pointing to possible mistakes should reflect an effort made by the teacher so as not to generate a repulsive student reaction, which, unfortunately, is not a rare practice in the so far teaching of natural sciences. The role of the teacher is, thus, doubled, as (s)he has to stimulate students to develop their competence, organize individual and team work, and be creative, as well as being a good critic who reviews both his/her own accomplishment and the work of others. Pointing to mistakes should be done as a function of acquiring new knowledge since mistakes are the result of low-level knowledge, not inability.

Taken with some reserve, the above, active approach to learning is possible at all levels of education, from elementary schools to institutions of higher learning.

The advantages of active courses are best observed among students who show a desire and good will to gain more knowledge, whether individually or with the help of others. Such active lectures can make it possible for students not as attracted to physics as to other subject to gradually develop a liking for physics and, consequently, get to love the subject. In order for this to happen, creativity must be encouraged in students, as well as the ability to critically review their own development and the work of others. Through presentations of students' results, the adoption of the concepts discussed in lectures can be ensured to a significant level that is much higher than achieved through standard class methods.

The method of active learning is entirely acceptable in the process of reviewing parts of the syllabi. As for acquiring new knowledge, the active learning method will not give satisfactory results unless the teacher undertakes the role of a guide and a corrector. This role should not be abandoned in the case of reviewing the already presented material, either. However, it is crucial when organizing classes in which new material is to be discussed, and that is why we emphasize it once more.

Another problem connected to the active learning method is the evaluation of students. This is not a new problem, as it accompanies any method. However, it is highly specific in active learning. Taking into account the so far experience, we will focus here on one segment of student evaluation, namely, the one when students evaluate themselves and their classmates. Comparison of the marks given by teachers and the marks given by students showed a high level of similarity and agreement.

The round tables proved useful in introducing some aspects of ecology classes and their implementation at the highest level. They were the places for presenting criticism and suggestions for improving course work, as well as presenting observations and problems pertaining to ecology but not covered in the workshop classes. There was also discussion about the conclusions in the presence of children and in their absence. The greatest attention was given to discussion about the workshops and active courses, but there were also suggestions concerning the adoption of themes for seminar and graduation papers in ecology. It was established that all the themes covered within the ECO PHYSICS framework are fully appropriate for producing such papers. It was also concluded that, in order to complete the educational process, cooperation based on *complementary* courses is necessary among those dealing with natural sciences (as is the case with ecology), as well as among those dealing with social and medical sciences and art (music, painting) [7]. Two initiatives were agreed upon: (1) radon measurement in Serbia; and (2) organization of ECO sections in schools. The first initiative started in cooperation with the Institute of Physics in Belgrade. Thirty participants were given each a small plate for radon detection which they put in specified locations in their neighborhoods, all over Serbia. The measurements were done in 2004. The other initiative – organization of ECO sections in schools – started with the purpose to ensure quality in teaching children ecological issues and to create a basis for organization of student teams at the republic level, which would allow for selection of the best representatives in various national and international presentations on environmental protection.

What we can see now after completion of the programs (seminars) is that quality in presenting and organizing lectures on ecological issues demands some level of knowledge of physics and other natural sciences. It is also related to the availability of a particular number of classes as a necessary prerequisite for organization of all lectures in an appropriate manner. The tendency of reducing the number of physics and other natural sciences classes (chemistry, biology) in elementary and secondary schools could have negative effects upon the quality and the level of students' knowledge, the goal which, we believe, is not anticipated to achieve through the educational system reform in our country.

Given the previous discussion, as well as the experience from the accredited seminar ECO PHYSICS, we propose the folloeing:

1. Integration of ecology-related contents, suggested through the lectures and workshops of this seminar, into educational curricula and syllabi of physics and other natural sciences, for the purpose of improving and achieving quality in teaching new modern courses;
2. Keeping the number of physics and other natural science classes at the level before reform, i.e. the year 2001, in order to obtain a higher quality basis for environmental studies;
3. Conducting complementary lectures in physics, other natural sciences, medical sciences, social sciences and art, as one mode of improving the covered material and rounding up a quality educational process.

CONCLUSION

The integration of environmental physics in the Serbian educational system (from elementary school to university) is highly needed. This results from the seriousness of problems due to man's interaction with nature. Solving these problems demands the knowledge of various aspects of physics, many of them interweaving with other sciences. As environmental physics deals with problems caused by man's interaction with nature, it is clearly connected with all parts of physics and other natural and social sciences. Physicists, however, do not like to say that they do research in environmental physics. Instead, they say they are concerned with climate physics, nuclear physics, and biophysics. When they have to relate their research with social and political problems, however, they are entering a field outside the common experience of a physicist, where, very often, there does not exist a developed researching methodology. Anyhow, physicists have the obligation to participate in the issues on social and political implications of their work.

The analysis of environmental problems, aimed at their reduction or prevention, is one way of explaining the role of physics. It has a special social meaning to students. Modeling, mutual integration of various areas of physics, and their connection with other natural sciences make environmental physics relevant, and that is something we physicists should have in mind in our common daily activities.

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EKOFIZIKA I OBRAZOVANJE

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Problemi u životnoj sredini nastaju usled interakcije čoveka sa prirodom. U cilju rešavanja ovih problema fizika okoline koristi puno podoblasti fizike. To istovremeno predstavlja motivaciju za uvođenje različitih aspekata izučavanja interakcija u životnoj sredini u nastavne programe. U radu smo analizirali motivaciju za izučavanje fizike okoline u školama u Srbiji kao i neke ideje za poboljšanje položaja predmeta koji sadrže ovu materiju. Posebno je istaknuta uloga specijalizovanih seminara u ovoj oblasti.