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Ethical Aspects of the Scope of Activity of Scientists and Societal Issues: the Case of Nanotechnology

Aspectos éticos del alcance de la actividad científica y cuestiones sociales: el caso de la nanotecnología

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ABSTRACT:
Accelerating influence of a human on the material world and its transformation on both molecular and quantum level urgently needs to be deeply considered from the ethical point of view. Humanistic approach to nanotechnology shall form a vision of a human as a creator, set sustainable progress goals, and to scrupulously project the consequences of implementation of the scientific and economic strategies, as well as their corresponding impact on the society and environment. The article covers the social and ethical issues on recent and prospective development of nanotechnology. The nanotechnology is considered one of the most ethically controversial scientific topics. Changes in the environment, and in human personality, with their consciousness and world view, shall depend on ecological and ethical aspects of science. The purpose of the study is to analyze the existing ethical principles of nanotechnology and their reliability. The comprehensive ethics of nanotechnology becomes even more important, as far as nanotechnologies become more and more accessible for individual researchers. The analysis showed that the concept of nanoethics is to be comprehensive, applicable and universal and shall try to avoid futuristic and unreliable development to exclude the possibility of theories.
Keywords: scientific progress; nanotechnology;

RESUMEN:
La aceleración de la influencia de un ser humano en el mundo material y su transformación tanto a nivel molecular como cuántico necesita ser considerada profundamente desde el punto de vista ético. El enfoque humanista de la nanotecnología debe formar una visión de un humano como creador, establecer objetivos de progreso sostenibles y proyectar escrupulosamente las consecuencias de la implementación de las estrategias científicas y económicas, así como su impacto correspondiente en la sociedad y el medio ambiente. El artículo cubre las cuestiones sociales y éticas sobre el desarrollo reciente y prospectivo de la nanotecnología. La nanotecnología es considerada uno de los temas científicos más éticamente controvertidos. Los cambios en el medio ambiente y en la personalidad humana, con su conciencia y visión del mundo, dependerán de los aspectos ecológicos y éticos de la ciencia. El propósito del estudio es analizar los principios éticos existentes de la nanotecnología y su confiabilidad. La ética integral de la nanotecnología se vuelve aún más importante, en la medida en que las nanotecnologías se vuelven cada vez más accesibles para los investigadores individuales. El análisis mostró que el concepto de nanoética debe ser integral, aplicable y universal y debe tratar de evitar el desarrollo futurista y poco confiable para excluir la posibilidad de teorías.

nanoethics; ethical aspects; societal issues; ethical speculations

Palabras clave: progreso científico; nanotecnología; nanoética; aspectos eticos; cuestiones sociales; especulaciones éticas

1. Introduction

The science implies the human brain to be a generator of ideas. For that reason, the role of human factor is highly emphasized by discovering more and more new intellectual potential abilities in human nature.

The profession of a scientist has its particular features. Principally, a scientist is an individual who has obtained a special professional training and relevant skills for the research work (both theoretical and practical). Besides, being a knowledgeable person, he shall consider the process of cognizing to be his highest value and the way for realization of his personality. The scientists are interested in the development of science. They are driven by their own ideas and are determined to develop their ideas freely. The scientific progress on its way appears to have manifold diverse social and economic consequences.

Alfred Rupert Sheldrake, an outstanding biologist, researcher in parapsychology, considers the mental power to be the universal reality being inseparable from nature. He appeals for the unity of scientists in social, behavioral and biological fields of science for their integration into the science of psychology for bridging the gap between theory and practice; for deepening the knowledge about the nature and a human; and for raising the awareness of national goals (Sheldrake, 1994).

Thus, the scientific research provides social value, and in case there is a concern about the consequences of the scientific discovery for the society, the ethical issue rises. It is even more important in developing countries that have no continuous tradition of scientific ethics.

In the Russian Federation there has been developed a methodological approach to relationship between the environment and the science.

A valuable contribution was made by N. F. Reimers, an outstanding scientist in the field of ecology, who considered ecologization to be “the process of consistent and logical implementation of a system of technological, managerial and other decisions; and this permits to increase the efficiency in use of natural resources and the conditions they are used under, with the quality of environment (or life) being improved or saved on local, regional, and global levels (within the scope of both single enterprise level and industry level)” (Reimers, 1990).

Having taken the definitions mentioned above into consideration, it can be concluded that the science is a sum of knowledge about the world around. It is the background for our vision of the world, the background which is defined by a philosophical notion “the world view”. The science is considered to be an instrument for reflecting the surrounding reality in human consciousness, in view; that is to say, the science is defined as an element of culture. It means that the science, being a creating power, serves for the prosperity and development of each individual. A human is believed to be the rationale for the scientific achievements.

The scientific breakthroughs shall be used for the human prosperity; nevertheless, they can cause adverse consequences. It depends on who handles the scientific achievements, and what purpose it is used for. For that reason, one shall remember that only the state scientific system aimed at prosperity for the entire nation is believed to guarantee the reasonable use and fair distribution of the scientific progress.

Under such considerations, the products of science according to Albert Einstein become “blessing, not scourge” for the humanity, and the science turns a powerful magic generator. Mikhail Alfimov, when being asked what music the orchestra of science plays, admitted that it is an atypical way of thinking, allegiance to the science, feeling of satisfaction, contentment from what you do, among other features which characterize the human nature (Hubarev, 1999).

The moral aspect of the scientist’s activity becomes more important, as far as different social and ecological negative effects of the scientific progress are turned evident. On the level of the philosophical and social generalization, the same process is theoretically observed in the research work covering relationship between the sciences and the values in general.

The famous "mind the gap" article, which is considered one of the most influential works on the issue of nanoethics, outlined that "while science is leaping forward, the ethics lags behind". The authors also indicates that the absence of the ethical principles of nanotechnology can lead to fear and rejection of nanoscience (Mnyusiwalla et al., 2003).

The development of nanotechnologies allows the humanity to increase the quality of its life, and, therefore, transforms conventional economies; and, as a result, formation of completely new environment. The development is characterized by its ambivalence. On the one hand, it is impossible for the humanity to evolve without the development of nanotechnologies, but, on the other hand, it is proved to be a potential power which can cause a disaster.

However, one should be rationale and avoid theories. A number of researchers on nanoethics emphasized that the debates around futuristic and, in most cases, unrealistic hypothetical dangers are theoretical as they restrict the contemporary science (Roache, 2008). The hypothetical theories are not just about ethical pros and cons – they have detrimental effect on every aspect of nanotechnology.

The development of industries with the use of nanomaterials may cause the pollution, due to the fact that they are characterized by high-speed reactivity and small particle size (1-100 nm) which have an extremely toxic effect on biological organisms. The concerns regarding their toxicity are directly related to their size and high specific surface area which result in a high-speed chemical reactivity and high capacity for the body penetration. Late evaluation of the importance and danger of nanotechnology can reduce the positive effects of their implementation (Antsiferov, Antsiferova, 2014).

Some of the recent studies draw the attention to the fact that the key principles of nanoethics are not "nanotechnology specific", but they are general for the science and technology studies (Shapira et al., 2010). Therefore, there are some doubts whether the ethical issues of nanotechnology are properly defined.

The current issues of nanoethics revolve around futuristic and science-fictional concerns. As stated in "Mind the gap revisited" work – there is a new "gap" in modern nanoethics. While a number of works still focus on ethical and societal issues of nanotechnology, the most of nanoethics is futuristic (Norman and Rip, 2009). That means that numerous efforts are wasted at the expense of more significant developments. Moreover, every single futuristic concept gives grounds for possible theories. The danger of hypothetic policies is real because unjustified interest to the extreme future scenarios casts shadows on the ongoing researches. And the nanoethics can serve as a tool for the discussion of controversial issues.

It should be noted that the approaches to the ethics of nanotechnology differ from country to country. For example, it was noted that there is a significant difference between the European and the Asian attitude (Dalton-Brown, 2012). The same is applied to the ethics of nanotechnology in the Russian Federation, as far as it has its own specific characteristics.

The work is aimed to determine the key characteristics of the era of nanotechnologies and the mechanism of nanotechnology evolution control.

2. Methods and data

The fundamental ideas of philosophy, culture, ecology and sociology form the methodological and theoretical basis of the research. There scientific and special methods of analysis (the principles of systematic approach, comparative analysis, and logical analysis) have been used.

The international market of nanotechnologies in the field of information technologies, biology, medical science, ecology, energy, materials, automotive industry, and agriculture has been analyzed.

The study covers the published works on ethics of nanotechnology found in Scopus and Web of Science citation databases, reports of the international conferences, statutes of the international organizations and research centers, as well as the works covering the analysis of the peculiarities and prospects of the nanotechnology field in the domestic economy. The outcomes of our own research on the effect of nanotechnologies on the environment and people's health within the domestic economy are taken into account. By studying the influence of nano-powders on the air in the operating area and on human health, the general properties of nano-particles, i.e., the size, the surface area, the structure, the heterogeneity, the permeability, the hydrophilic behavior, the hydrophobic behavior (a water-repellent property), and the chemical composition have been studied; as far as these characteristics influence the elimination rate, and, therefore, the health of working staff.

To draw up specific recommendations for the improvement of nanotechnology industry management, there has been studied the experience in state regulation of a number of foreign countries, having their priority of nanotechnologies development among the others.

The concept of the network approach to nanoethics described by Ibo van de Poel has been used (Van de Poel, 2008). The positions of the two main methodological approaches, which consider nanotechnology as negative and positive development, have been analyzed.

Experience in creating REC in PNIPU, which is the organizational form for integration and coordination of academic, research, innovation and innovative capacity units, is taken into consideration and used to improve the personnel management.

3. Results of the research

The development and application of new materials can improve the quality in such life activity areas as medical science, water purification, environment protection, and energy generation (Antsiferova, 2011). The outcomes in nano-medicine are implied to provide the society with the answers for a number of unsolved pressing issues in modern medical science (Ertheringe et al., 2013). The recent data shows that nanotechnologies enabled the production of 247 nano-medical products, which either are already duly approved, or are at different stages of clinical research (Alexiou, 2012).

Nanotechnology shall play an important role in solving issues related to the environmental protection due to creation of green technologies, sewage treatment units, and use of nano-facilities in systems of product research and product control, as far as in the research on chemical waste.

Nowadays there are about 2000 nano-materials which are produced worldwide. Nevertheless, the long-term effects of nanotechnology are yet insufficiently studied. At the same time, the small size of nano-particles provides the materials with physical and chemical properties of a high efficiency. Another trend is that the developed countries invest greater and greater funds in nanotechnology research.

The nanotechnology gets the direct state investments in more than 60 countries worldwide (Roco, 2007). For example, in the Russian Federation the volumes of nanoproducts manufacture have reached about 900 mio. rubles in 2015. In the long-run, the volumes of production imply to be increased up to $ 1,2-1,5 trillion (Liashenko, 2008).

The USA, EU, Japan, India and China also invest sufficient funds in the development of nanotechnologies. The amount of the investment in monetary equivalent is known to have reached $ 4.37 billion in 2003, but in 2006 the sum was estimated in $ 6 billion (Kryvorotko, 2012).

These countries consider nanotechnology as the most recent and economically important development in science and technology (National Science and Technology Council, 2000). The problem is that such investments in the absence of discussion between governments and citizens lead to hypothetic views and unjustified fears.

The use of nanotechnology in computing means multiple improvement of datalink system, invention of new storage devices, creation of biosensors able to control the condition of organism, creation of new communication devices, and new semiconductor technology (i.e., carbon nanotubes).

The implementation of energy-efficient technology in production is closely related to development of nanotechnology due to the fact that the nanotechnology is proven to have led to the development of eco-innovations which are likely to be used for solving a wide range of issues within the global scale, e.g., waste-free production, etc.

According to the statistical data given by the Ministry of Research, Science, and Technology of New Zealand in the report titled "Biotechnologies to 2025", the development of nanotechnology is implied to be an essentially important direction of creation of a system of beneficial, from the economic point of view, and energy efficiency technologies for the purpose of recycling of biomass; for instance, biofuel, bioplastic, etc. To be more specific, in 2010 a share of recycled plastic was 10% of plastic market. According to the report, by 2020-2025 the share is expected to be increased up to 20% (Biotechnologies to 2025, 2005).

In 2007 a broad coalition of civil society, public interest, environmental and labor organizations concerned about various aspects of nanotechnology's human health, environmental, social, ethical, and other impacts, submitted the Declaration Principles for the Oversight of Nanotechnologies and Nanomaterials, stipulating eight fundamental principles that are believed to provide the basis for adequate and effective oversight and assessment of the emerging field of nanotechnology, including those nanomaterials which are already commercially used worldwide. These Principles are The Precautionary Principle, the Mandatory Nano-specific Regulations Principle, the Health and Safety of the Public and Workers Principle, the Environmental Protection Principle, the Transparency Principle, the Public Participation Principle, the Inclusion of Broader Impacts Principle, and the Manufacturer Liability Principle (Aluskina, 2011).

E.I. Oliynich points out the increasing impact of nanotechnology on healthcare and sustainable production. The scientist considers nanotechnology to improve the oversight of environmental safety, for instance, by virtue of biosensors creation (Oliynich, 2009). Thus far, a stated fact is solving global problems with the use of nanotechnologies. The scientists from the University of Ulm have worked out microelements which are proved to prevent the depletion of ozone layer (Liashenko, 2007).

The idea of providing the humanity with all necessities by the extraction of the particles from the substances of environment, such as sand, water, etc., accomplished by nanorobots, is deeply believed by the humanity to fight hunger, diseases, and physically demanding operations. B. Chumachenko points out that by the beginning of the second half of the 21st century the industry wastes are predicted to be turned into freshly renewed raw materials by means of molecular corps robots. Accordingly, it is expected to be possible to create favorable conditions for waste-free production and sustainable agriculture (Chumachenko, 2001).

However, a number of scientists predict that next nanotechnology generation can become a destructive force because of assumed ability to influence negatively many fields of activity of a human. The first official document which raised the issue of potential global danger of nanotechnology and the "grey goo" scenario was the report titled "Nanoscience and Nanotechnologies: Opportunities and Uncertainties published by the Royal Society and Royal Academy of Engineering (RS-RAE) in the UK" (Dowling et al., 2004). The positive effect of such theories which are considered hypothetic by most scientists is that they made the governments to invest time and funds in the researches devoted to the ethics of nanotechnology.

Significant health, safety, and environmental hazards are the pressing issue raised from the use of nanotechnologies because of barely known impacts of nanotechnologies and inadequate means to detect, track or remove such materials. For instance, in 1930, asbestos was widely used in the industry by manufacturers and builders because of its desirable physical properties, yet it is now known that prolonged inhalation of asbestos fibers can cause serious and fatal illnesses including malignant lung cancer, mesothelioma, and asbestosis (a type of pneumoconiosis). Mounting evidence indicates that a rigorous in-depth research on the properties of nanoparticles and their impact is urgently needed to be conducted to avoid repeatable failure (Seaton, 2010). Contentious debates were held in the

USA, the European countries (esp. Germany), Japan, India, the Russian Federation, etc. Thus, since 2003 the issue of the menace of nanotechnologies to the environment and, respectively, the human health has been discussed in The Bundestag, the Royal Society, and the Royal Academy of Engineering (London). Consequently, the corresponding recommendations for the elimination of potential unacceptable risks posed by the use of nanotechnologies have been made. Since 2003 and then, the programs of research of the negative impact of nanoparticles have been established in such countries as the USA and Germany. Nevertheless, the programs and the further discussions could not be likely to eliminate the fears regarding the safety of the use of nanotechnologies (Antsiferova, 2014).

Outstanding examples of positive use of nanotechnologies can be easily found in such spheres as medical science, biology, and cosmetics, in which the typical foam being characterized by its disinfecting properties, are widely used. The disinfecting properties can be explained by formation of a nanoparticle, a micelle, or micella, an aggregate of surfactant molecules dispersed in a liquid colloid, therefore, soap can be correspondingly defined as a miracle of modern technology, with nanomaterial being used in modern medical science and cosmetics.

Medical diagnosis is proven to be another outstanding example of the applicable use of nanotechnologies. Specifically, with the help of the nano-apparatus used in the diagnostic practice, a patient can be diagnosed by detecting and examining the smell. Moreover, biocompatible materials are widely used in dentistry; therefore, due to the materials are put into production line, nearly 100 000 000 units of mobile cells have been recycled for the last few years in Europe (Sigova, 2009).

As nanotechnology is a developing sphere, a hypothetical scenario of the Judgment Day has recently emerged predicting that totally uncontrolled nanorobots shall absorb all of the biomass on the Earth giving rise to copies of themselves, i.e., replicating. The term "nanorobots", or the "grey goo", is defined as a large mass of self-replicating nanomachines.

The term of "grey goo" was pioneered by Kim Eric Drexler, an American engineer-innovator widely known for popularization of the potential of molecular nanotechnology (MNT), who said "Imagine such a replicator floating in a bottle of chemicals, making copies of itself…. Thus, the first replicator assembles a copy in one thousand seconds, the two replicators then build two more in the next thousand seconds, the four build another four, and the eight build another eight. After ten hours, there are not thirty-six new replicators, but over 68 billion. In less than a day, they would weigh a ton; in less than two days, they would outweigh the Earth; in another four hours, they would exceed the mass of the Sun and all planets combined—if the bottle of chemicals hadn't run dry long before" (Moyer, Storrs, 2010).

Despite masses of out-of-control, self-replicators can be neither grey nor mucilaginous; with the term of "grey goo", it is pointed out that replicators being capable to eliminate life are expected to turn out to be "superior" within the evolutionary terms.

It becomes clear that the ethical, the social, and the political aspects of nanotechnology are being paid duly fresh attention (Donal, O'Matura, 2009). In the work (Tsyra, 2013) the author makes his suggestion on elicitation of the focused and result-oriented development of nanoethics. It is shown that there is an evident necessity for the issues of moral and social responsibility and security of an individual to be reached within the moral humanistic terms.

Accelerating technical progress greatly seems to develop the nations and their societies in different directions, with varying degrees of success. In particular, a profound nanotechnology is very likely to be widely available only for a limited number of top developed countries with modern scientific base; consequently, the scientific revolution is believed to extend the gap between the developed and poorly developing countries. Nanotechnology is expected to change the lives of ordinary poor people to worse (Donal, O'Matura, 2009).

Among others, a number of sufficient inequalities can appear in the division of the benefits from nanotechnology-based medicinal product. Currently, there is an evidence found in a number of countries that different layers of society face unacceptable inequality in being provided with fair health care. The social inequality can be gradually aggravated by proceeding development of nanotechnology medicine, for the reason that a newly produced efficient medicinal product is more likely to be expensive. In ethical terms, it is rather widely noticed that private human life is to be protected from any form of interference equipped according to the latest spying technologies. Nanotechnology seems to broaden the existing range of distinct possibilities of invisible collection of confidential data; therefore, triggering a new formidable technique for collecting the data of private lives, needless to say, is the manufacturing and military espionage. The possibilities for modeling and creating the techniques to influence on human brain directly (therefore, nervous system) seem to be under deep consideration by a number of specialists, making it real to substitute passive watching for an active, but visibly unnoticeable control.

In terms of human rights, a right to privacy is likely certain to be under risk of infringement more often, specifically, µTAS technologies, in particular, lab-on-a-chip (LOC) devices, enable to diagnose a huge number of patients, even predict the potential illnesses, correspondently, creating massive databases of population health. Thus, it can be technically possible for the employers or insurance companies to find out any private genetic predispositions and use the data for manipulating their employees or customers.

Application of nanotechnologies is expected to result in a quite considerable increase in human life duration that is certain to create a number of ethical issues. To give an example, from the ethical point of view, it remains absolutely blurred what should be defined as a quality life in terms of long-lasting existence. Moreover, in future, in cases of an emergency or fatal diseases it might be possible to catalyze a “frozen” condition of a patient, i.e., all his physiological processes will be stopped on the molecular level, consequently, losing all prospective about moral limits in those cases where the technologies can be applied.

Another example, applying the latest achievements in artificial intelligence creation, genetic engineering, and nanotechnologies for accelerating the evolution of humankind, trans-humanists have given roots for an incredible idea of creating an immortal Homo Sapiens individual by means of “fusion” of a human body and robotic devices.

From the ethical point of view, there are contentious debates about the creation and the scope of hypothetically prospective functions of a cyborg, i.e., an artificially created fusion of a human body and modern technical systems. Futuristic theories expect that human consciousness will be saved in computary equivalent. It makes us think over whether a technical (respectively, partially technically, or partially biologically designed) creature like a “machine-human” can claim the status of a human (Bacchini, 2013).

A number of works (Kermisch, 2012; Grunwald, 2012; Grunwald, 2010) defines nanoethics, and prove the evident interrelationship between a human and knowledge. Nanoethics is determined to be the solution for freshly appeared and barely appearing disputes between a human and accelerating progress. Moreover, the scientists insistently explore the degree nanotechnologic adverse effects on ecology.

Danger of an ecological catastrophe has considerably strengthened an overwhelming feeling of the necessity for the scientists to follow certain ethical principles. It undoubtedly refers to drastic, in a definite way inconvertible changes in the environment caused by the aggressive attitude to nature. Being generated by modern science, the global environmental problems are being positioned as burningly pressing the globally scaled social, technological, and moral issues.

In the conditions of increasing anthropogenic stress on the environment and its high anthropogenic load intensity, nanomaterials effect a human directly in combination with contaminants of environmental compartments, and have typical degree of dispersion.

The components of nanomaterials – nanoparticles, nanoplates, nanofiber – can get to environment in many ways within their complete life cycle – through the process of their manufacture, transportation, application, and utilization of finished products with nanoparticles in their composition, among others. Even in case they are applied as the components of solid materials, they are possible to get into the environment because of their fusion, processing, and storage, or during the period of their use. When nanoparticles get into the air they can form aerosols which suspend in the air for long-term periods. Such aerosols may force into living organisms from the air while breathing, through the skin, and through gastrointestinal tract, among others. Through absorption from aerosols with the plants, the nanoparticles actively force into flora; thus, being the main source of food for the animals and birds, force into fauna. The nanoparticles dispersed in the air may consequently get into soil, lakes, rivers, and so forth, through precipitation with rainwaters and through their absorption correspondingly. In particular, nanoparticles may get into soil through a variety of ways, e.g. from the atmosphere (through precipitation, adsorption, and adhesion), from the hydrosphere (through dissolution, sedimentation, adsorption, and adhesion), and, thereafter, from the organic substances (over their living and putrefaction afterwards). Getting into soil, the nanoparticles may adversely affect its fertility by changing its micro-chemical composition. From the soil the nanoparticles can get into benthos (the cluster of organisms which live on, in, or near the seabed, or the riverbed, and so forth), thus, through the food chain they can get to algae and other organisms. The total effect on living organisms may result in either strong toxicity (potentiation), or antagonism depending on the mechanism of action and the sources of action. Currently, an adverse effect of nanoparticles is under deep interest of scientists who try to identify how nanoparticles interact between the food chains of not only a human, but also an animal creature.

There is no doubt that human exposure to toxic nanoparticles, owing to the fact that they can reach the cells of the epidermis, and thereafter get into more deep layers of cells or connective tissues through the perspiratory glands, bulbus pili, and even the nerves. Despite the healthy cells of the epidermis form a good natural barrier to adverse intruders, the nanoparticles may get to and be absorbed by the gastric mucosa (the mucous membrane layer of the stomach) and, consequently, migrate from the blood into the tissues, and organs (Antsiferova, 2013; Antsiferova et al., 2012).

Nanoparticles can translocate through the circulatory, lymphatic, and nervous system and can accumulate in tissues and organs, including the brain, the liver, the kidneys, the spleen, the bone marrow (medulla ossium), the nervous system, and the lymphatic system. The work (Grunwald, 2010), with an evidence of conducted medical examination, concludes that people following up to three-year period long exposure to nanoparticled non-ferrous metals suffer from chronic bronchitis. A number of patients are diagnosed with disorders in the nervous system; hence, there are some suffering from vegetative-vascular dystonia, or abnormal function of endocrine system, among others. It is known that the materials or components made of the metal powders can have an adverse effect on the above-mentioned organs.

Due to the structural projections for evolution of science, in particular, engineering, natural resources, biosphere in complex, economics, etc., human ecology is forced to play a synthesizing role.

A strong interrelation between the sciences studying environment (such as geology, geography, biology, etc.), and the sciences developed to transform the environment (i.e., engineering) seems to be urgently needed. The science becomes more widely characterized by its freshly appeared trend concept which can be called ecologization (Trushkov, Okonskaya, 2014).

It should be considered that research predictions which seem to prevail in the ecological research works, are not likely to provide a sufficiently complete pattern. It is necessary to simultaneously develop normative forecasts (Unguryanu, 2013; Grunwald, 2005).

In the conditions of ecological crisis the main development directions of the biosphere, the society, and the science are closely intertwined, that it is impossible to preserve their original status – the status of self-developing systems which used to seem barely linked. Thus, here is where a holistic, more complex system starts its roots - the "society-science-biosphere" system. The environmental ethics raises a variety of entirely different issues due to the necessity to preserve the biological and social life on the Earth. The science with ecologization-viewed concepts becomes an instrument for the society to organize themselves rationally, as well as to build a strong beneficial relationship between them and the environment. However, this instrument can be applied in accordance with the peculiarities of the society structure (Fiedeler 2010, Grunwald, 2004).

Correspondingly, ethical responsibility for nanotechnology effects, being studied by a scientist in a scrupulous way, becomes a science coordinator. Ecological approach changes the scientific work content, and, thus, its problematics. At the same time, the scientist's activity achieves new properties, as far as the society is strongly influenced by the consequences of scientific progress. Ethics expands further on science forcing it to reconsider its own history-long compiling system of values.

Therefore, the following information should be taken into account:

- the society shall raise awareness of nanotechnologies and nanomaterials' toxicity among the scientists and manufactures handling them;
- nanotechnologies must be secure, efficient, and facilitate sustainable development;
- nanotechnologies must evolve in an exposure-free manner;
- information on nanotechnologies must be freely available for each party concerned;
- nanotechnologies shall meet the latest standards in science and technology;
- nanotechnologies shall facilitate creativity and flexibility for innovations and development;
- manufacturers of nanomaterials shall be responsible for the negative social, health, and environmental consequences.

However, the situation started changing. Contentious debates on nanotechnologies and their potential adverse effects play a considerably important role in many countries, especially in the USA and the European countries. Since 2003, the Bundestag have been discussing the issues related to nanoparticles basing on conducted research works in the framework of social assessment of technology (ESA) (Paschen et al., 2004). Research works run by the Royal Society, and the Royal Academy of Engineering (London) allowed to make a variety of applicable recommendations aimed at completing the knowledge about nanotechnologies and, consequently, minimizing the possible risks. According to these recommendations, the predominant requirement is to apply a preventive approach to nanoparticles manufacture. Correspondingly, the UK government faithfully promised to facilitate more intensive research on risks the nanotechnologies can bear, to harmonize the existing rules of application of nanotechnologies (Antsiferova, 2010; Fiedeler et al., 2010), and to raise the public awareness of nanotechnologies and further discussions on them, among others. At the same time, the USA and Germany have initiated programs of research on adverse effects of nanoparticles (Moyer, Storrs, 2010; Grunwald 2004, Paschen et al., 2004).

In Russia, the resolution No. 54 "Of control over the products manufactured with nanotechnologies or containing nanomaterials" by Chief State Medical Officer of the Russian Federation, dated 23.07.2007, was approved, stipulating that it is obligatory to develop a concept of the research on toxicity, and methodology for assessing the hazard of manufacture, use, and utilization of nanomaterials, and products manufactured with nanotechnologies (Rakhmanina, 2009).

The work (Fiedeler et al., 2010) evidences that it is the government to regulate ecologically-related activities in production of nanomaterials, and it stresses that education, science, and manufacture must be mutually-integrated.

One of the ways which plead in favor for finding the solution of this challenge is the ecological education approved by the Presidential initiative with its aim to create programs for study and sharing the knowledge for the industry to form solely mutual technological culture for the new generation (Antsiferova, 2013, Troshin et al., 2015). In 2012 there was rendered the assistance in staff retraining by «RUSNANO» (i.e., Nanoindustry development program in the Russian Federation within up to 2015 running scope) (Concept of Education 2009). Development strategy 2015 stipulates the enforcement of drastic measures to adapt scientists, specialists and lecturers who conduct fundamental and applied research work to the new high-technology equipment, taking their line of activity peculiarities into account.

Aimed to create stimulating conditions for a number of scientists and academic staff to be increased, and to get the youth involved in the scientific research activity, in scientific activity, and in the development of high technologies, and the heritage of the scientific scholars to be preserved by future generations, there was approved the "Scientific and academic staff for innovative Russia" federal 2009–2013 target program (government decree No 568 dated 28th of July 2008). The main tasks of this program are as follows:

- to create favorable conditions for scientific and academic staff to be upgraded in their expertise, and to construct an efficient system of scientific work motivation;
- to create an incentivizing system for getting the youth involved in the research activity, in scientific activity, and in high technology development, with the military relm, energy industry, aerospace field, atomic complex, among others, to be top-priority high-technology industries for the Russian Federation, and to further solidify their position in these fields;
- to create the system aiming at enriching the scientific and academic staff (Program for Development of Nanoindustry 2015).

One should understand that the ethics of nanotechnology is a complex subject. The analysis of the published literature shows that there are multiple and often contradictory theories of nanoethics. That is the reason why the ethics of nanotechnology shall be incorporated in the teaching process of young scientists. It is necessary to give the complete consideration for every theory and methodological approach. The biggest issue is finding the balance – how to integrate the ethical questions with decision-making without any harm to the innovative thinking. In their work, Barakat and Jiao (2010) suggest that the nanoethics should be taught on the basis of engineering ethics and consist of the following subjects: 1) The basics and concepts of Ethics; 2) Nanotechnology specific ethics; 3) Applications of ethics in nanotechnology products and processes.

Moreover, scientific and education centers (SEC) prove to have all prospects of gaining the respect of being the most effective form of the scientific staff training and retraining. That being the case, existing scientific and education centers are proved to be accepted as a prototype of an innovative educational structure (Antsiferova, Esaulova, 2013).

Another question to answer is how to make people regard nanotechnology as a safe and promising technology. The process of nanotechnology development inevitably leads to the point when nanotechnologies shall enter the market. And whether the nano-product shall have success or not depends on the attitude to the nanotechnology as a whole by the general audience. The recent studies show that there is a huge gap between the visions of the experts and potential consumers (Gupta et al., 2015). And that is the question that only ethics is able to address.

There is a number of legislative acts with the set framework for the research in nanotechnology. These acts are of utmost importance to the developed countries, in which a number of private research institutions also have access to nanotechnology. These issues are highlighted by the difference in the regulatory approaches of the Western and the Eastern countries. The European committee has adopted the Code of conduct for responsible nanosciences and nanotechnology research in 2008. However, while most private organizations share the views only the small number of them have actually adopted the document officially. They take the advantage of democratic freedom and take the Code as the recommendation only. Meantime, in China and India the field of nanotechnology is completely controlled by the government. However, according to the recent researches the ethical view is "innovate now, regulate later" (Fautz et al., 2015). Such position is aimed at the obtaining the economic advantages as soon as possible, but it implies a number of hidden ethical concerns.

The evidence on the opinions of the scientists working in the field of nanotechnology shows that they consider the ethical issues of nanotechnology to be as important as its scientific dimension is. The majority of the scientists agrees that every researcher shall take into account the societal consequences of his research and bear the ethical responsibility for it. Moreover, the poll indicated that the ethical education is considered vital for the future generations of scientists (McGinn, 2008). That fact shows the shift from the social absenteeism of the scientists that used to regard the innovation as a supreme value.

4. Conclusions

Having analyzed scientific papers and having systemized a variety of points of view, it can be come to the obvious conclusion that evolution of nanotechnology is proved to produce the cultural, environmental, and social results that have ambiguous character. Human interference into evolutionary world at quantum level must be carried out within ethics-based paradigm, with in-depth analysis done, scientific, social, environmental and economic consequences projected.

- To provide the environmental and ethical culture of safety, it is necessary to:

- Facilitate the relationship between the natural sciences, the technology and the humanitarian sciences.

- Consider ethical responsibility for the effects of nanotechnology as science coordinator.

- Face a variety of freshly raised issues due to an urgent necessity to preserve the biological and social life.

- Create the system of enriching the scientific and academic human resources.

- Create modern human resources policy for coordination of the research on nanotechnology in order to eliminate the barriers in the way of growing the market of nanoproducts manufacture and service;

- Develop the principles of ethical and ecological protection, along with precautionary measures that shall include ecological education.

The importance of the societal aspect of nanoethics lies in the fact that the positive effect of its use can be immense. It is essential to avoid the theories around futuristic scenarios, while developing a coherent system of specific ethics of nanotechnology.

Educational strategies for nanoethics shall be based on the existing engineering ethics adding specific issues of nanotechnology. It is very important to preserve the balance between innovation and regulation. Thus, the main task of nanoethics is to ensure that it is a safe yet a cutting-edge sphere.

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