УДК: 504.75.05
DOI: 10.12737/6630

Sustainable Management of Chemicals in Russia — Improving the Use of Chemicals and Minimizing the Danger for Nature and Human Beings

A. AtKisson, *Senior Fellow*[1]
A.S. Makarova, *Leading Researcher, PhD*[2]
N.P. Tarasova, *Director of the Institute of Chemistry and Problems of Sustainable Development, Member of the Russian Academy of Sciences, Doctor of Science (Chemistry), Professor*[2]
S.V. Makarov, *Associate Professor, PhD*[2]

[1] Center for Sustainable Development, Uppsala University, Sweden
[2] D.I. Mendeleev University of Chemical Technology of Russia

e-mail: annmakarova@mail.ru

Keywords:
sustainable development,
chemicals,
environment,
risk,
management.

In this article we have analyzed the system of chemicals management in Russia. We have used the TSIS ("Trends & Indicators, Systems, Innovation, Strategy") method as a tool for the analysis of the current state and for the elaboration of the concept of sustainable management of chemicals in Russia. The analysis showed that sustainable management of chemicals in Russia today might most effectively consist of:

- *The creation of the legal framework, including legislative support for many existing best practices;*
- *Involvement of chemicals businesses and the general public in the process of promoting management, including creation of a culture of consumption and production of sustainable chemicals;*
- *In addition to the state regulation, the implementation of business initiatives and the tools of self-regulation for business.*

We have found out that the organization of sustainable management of chemicals in Russia will require changes in chemical production (including internalizing the expenses now externalized to nature) and the consumption chains. The time to act is now, otherwise the planned growth in the production and consumption of chemicals is very likely to lead to catastrophic consequences both for the nature and for the human health. For the most part, best practices in sustainable management of chemicals (practices that could have a positive impact on the situation) are known in Russia. However, their effectiveness is low. The situation reflects the absence of a Russian legal framework on chemicals safety, and the current low motivation of business to adopt the best practices in the absence of clear signals from the state that it should be so. In order to create the system of sustainable management of chemicals, the state authorities should not only use the state regulation, but also actively promote and develop business initiatives and involve the society.

1. Introduction

"*We stand at a critical moment in Earth's history, a time when humanity must choose its future. As the world becomes increasingly interdependent and fragile, the future at once holds great peril and great promise*". This text from the Earth Charter can be fully applied to management of chemicals. These words are supported by the text from Agenda 21 that was adopted during the United Nations Conference on Environment and Development (UNCED) in 1992, and reaffirmed in 2012 by the United Nations Conference on Sustainable Development. Section 19 of Agenda 21 states that "*a substantial use of chemicals is essential to meet the social and economic goals of the world community and today's best practice demonstrates*

that they can be used widely in a cost-effective manner and with a high degree of safety". But at the same time, Agenda 21 notes that chemicals can be (and in some areas have become) the cause of adverse effects on human health and nature.

In 2009, in «Nature», the article was published that described estimations of the main anthropogenic pressures [1]. "Planetary boundaries" have been identified in nine key parameters: climate change, ocean acidification, ozone depletion, nitrogen and phosphorus cycles, global freshwater use, change in terrestrial ecosystems, the level of biodiversity loss, the concentration of emissions of aerosols and chemical pollution. For seven of the nine parameters boundary values were defined. Going beyond the boundary values can lead to irreversible changes in the biosphere. But the boundaries have not been determined for aerosols and chemical contamination due to their complexity. Lack of boundaries for chemicals leads to a lack of knowledge about the global risk and to a lack of ability to manage risk. But today, chemical pollution is a serious concern in the world. Planetary boundaries are one of the foundations of the sustainable development goals [2] of environmental protection and the criteria for their achievements. However, the absence of planetary boundaries for chemical pollution actuators leads to a lack of goals and criteria in this field.

Thus we need an approach to sustainable management of chemicals. Sustainable management of chemicals is a process that equally takes into account nature, economy, society and individual well-being. Sustainable management of chemicals is a top priority for many international associations. For example, APEC Chemical Dialogue (CD) includes "Encourage Chemical Product Stewardship, Safe Use and Sustainability" [3] among its main goals. CD developed "The Principles for Best Practice Chemical Regulation" containing recommendations for sustainable management of chemicals. According to these principles, sustainable management of chemicals should [4]:

- be minimally required to achieve stated goals;
- adopt a risk management approach to developing and administering regulation;
- be flexible, not prescriptive, and be compatible with the business operating environment;
- be science-based.

Russia, being the active APEC member, can use these principles in the national system of sustainable management of chemicals. A priority for Russia lies in refocusing economic strategy away from mining raw materials to high-tech chemistry. This goal is noted in the Development Strategy for Russian Chemical and Petrochemical Industry through 2015 (hereinafter DS 2015) [5] and the Development Plan for Russian Gas and Oil Production for the period until 2030 (hereinafter — Plan 2030) [6]. Achieving this goal will increase the use of chemicals. But implementation of this goal should be pursued in a way that does not negatively affect nature and human beings. Adopting sustainable management of chemicals is a way for Russia to combine the development of its chemical industry with the protection of environmental and social well-being. The aim of sustainable management of chemicals in Russia can be articulated as "improving the use of chemicals and minimizing the danger for nature and humans".

2. Creation of sustainable management of chemicals in Russia

We are using the TSIS method [7] as a tool for the creation of sustainable management of chemicals in Russia. This method took its name from the first letters of the following four stages:

T — Trends and indicators. This stage includes analysis of available data on the effects of the object of research on environmental, economic, societal and individual well-being dimensions, and identifying current trends.

S — Systems. This stage consists of system model construction and identification of critical cause-effect relationships within the system, with a subsequent search for leverage points (system components where the introduction of any changes and / or innovations can be the most effective).

I — Innovation. This stage includes selection and evaluation of stability-improving innovations that can contribute to sustainable development.

S — Strategy. This stage includes building a common strategy for the implementation of selected innovations.

3. System description

The object of our research is "The process of chemicals management in Russia". We used a Mind map (Fig. 1) to define its framework.

When we created the Mind map, we developed the answers to four basic questions:

WHO are the main stakeholders involved in the process of chemicals management? The Mind map defines state, business and Russian and international society.

WHAT exactly is exposed to risk or damage during the cycle of chemicals management? The Mind map defines the environment (air, water, soil and biota) and the health of employees (maintenance staff) and general public.

WHEN do chemicals affect something or someone, or can there be other external factors? In accordance with international "from cradle to grave" principle, chemicals management should be carried out throughout the full industrial life cycle: research, manufacture, storage, transportation, sale, use (including domestic use) and waste disposal.

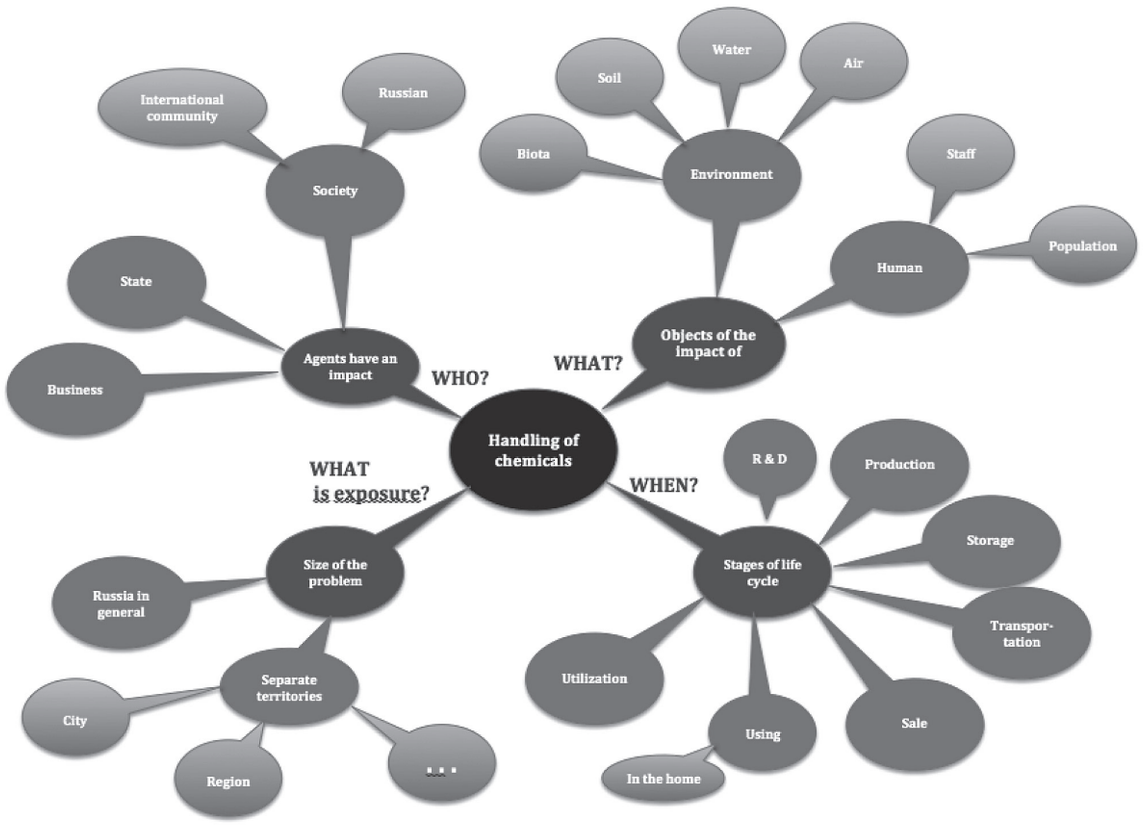


Figure 1. Mind map "The Process of Chemicals Management in Russia"

HOW do the chemicals affect somebody/something? Chemicals can affect the whole country or separate territories (e.g. region or city).

4. Indicator Development

At the stage **I** — Indicators, we have chosen several indicators that as we believe, can help to draw conclusions about the sustainability of the process of chemicals management in Russia. We choose indicators for four major TSIS-defined categories: nature, economy, society, well-being.

Information sources: Federal State Statistics Service (Rosstat), Unified Interdepartmental Statistical Information System (UISIS), Report by the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), Report on the Activities of the Ministry of Industry and Trade of the Russian Federation (period 2004–2011), etc.

Due to the great amount of different information in these sources, we have further divided up the search categories into assets (important existing positive aspects, or development trends, that you wish to maintain or continuously improve), current and possible future concerns (emerging or chronic problems) and aspirations (future, hoped-for elements or conditions that you wish to see in your system) for the abovementioned factors as a preliminary step for Indicators stage (Table 1).

Table 1

Assets, Concerns and Aspirations

	0B Assets	1B Concerns	2B Aspirations
3B Nature	4B Reducing amount of hazard chemicals in air, water and soil	5B Great number of "dirty" cities	6B Air, water and soil condition conforms with standards
7B Economy	8B Raising the volumes of production	9B Resource-based economy + uncontrolled export of chemicals (including hazardous chemicals)	10B Only safety chemicals are manufactured and in-demand
11B Society	12B Raising the salary and number of people working in chemical plants	13B Raising the number of incidence and occupational diseases	14B Chemicals do not affect people negatively
15B Well-being	16B Using chemicals for rising quality of life	17B Chemicals adversely affect nature and humans	18B Chemicals are used in non-hazardous way

Using Assets, Concerns and Aspirations and statistical data, we derived a set of relevant indicators:

- **nature**: pollution levels (e.g. emissions of pollutants into the air and discharges of polluted waste water), the amount of produced/recyclable waste, water and electricity consumption;
- **economy**: chemical volumes and sales income, export/import dynamics, funds spent by chemical manufacturers on environmental measures, on environmental fees and fines and expenses on modernization of chemical production and innovations;
- **society**: number of people working at chemical plants, average salary;
- **well-being**: product consumption level, life average-expectancy, numbers of accident victims, statistics on occupational diseases, living communities (cities) pollution levels.

The examples of trends for selected indicators are presented in the Table 2. Where possible, we have forecast trends.

Table 2

Example of Indicators and Trends for the Process of Chemicals Management in Russia

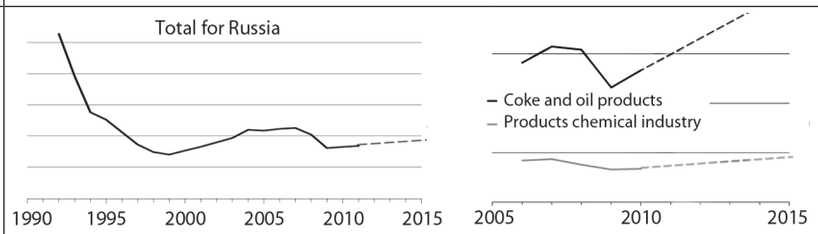
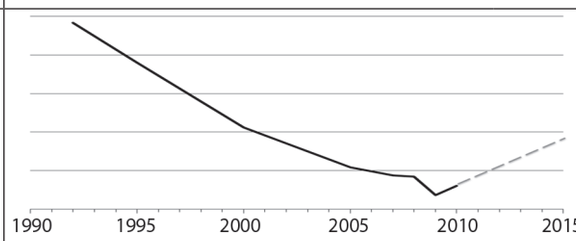
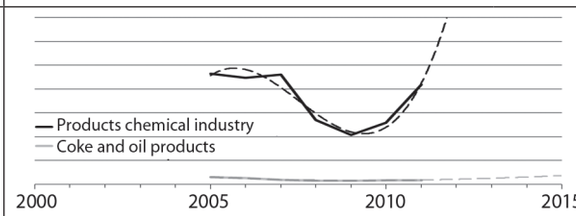
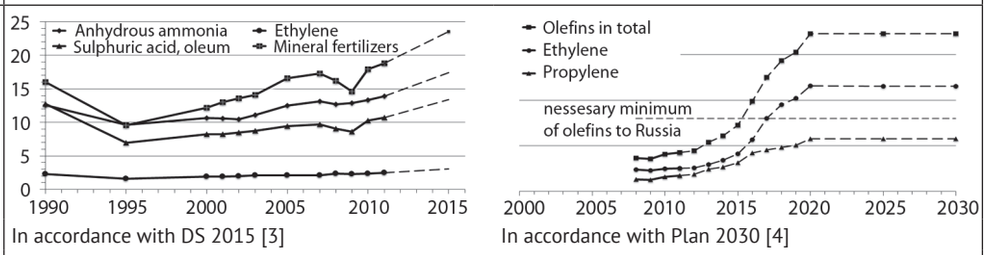
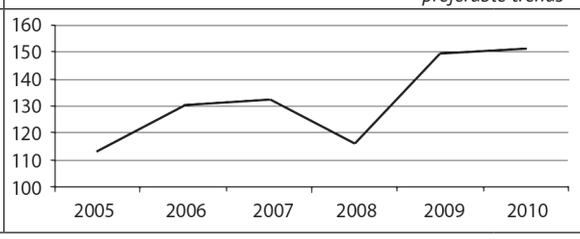
Category	Name of Indicators	Trends
Nature	Emissions of pollutants into the air from stationary sources (broken lines are indicating the trends)	 *undesired trends*
Nature	Sewage discharge	 *undesired trends*
Nature	Production and consumption waste	 *undesired trends*
Economy	Chemicals-volumes of production	 In accordance with DS 2015 [3] In accordance with Plan 2030 [4] *preferable trends*
Economy	Ratio of import to export of chemicals in %	 *undesired trend*

Table 2

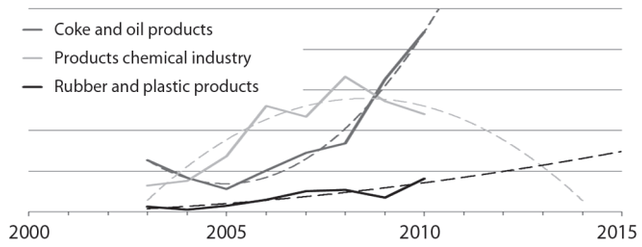
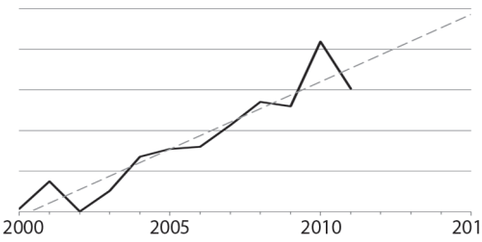
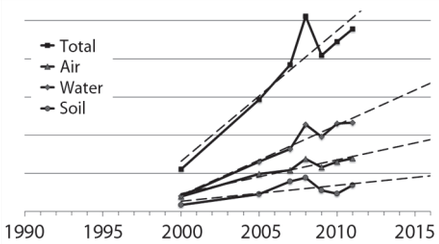
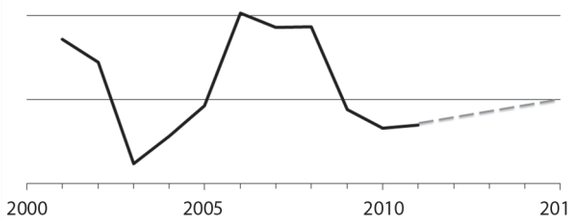
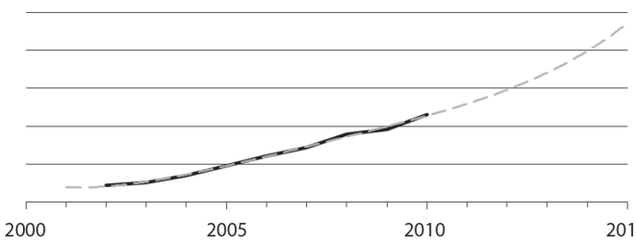
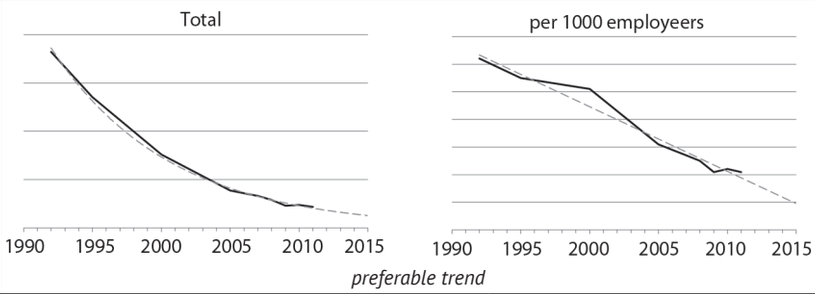
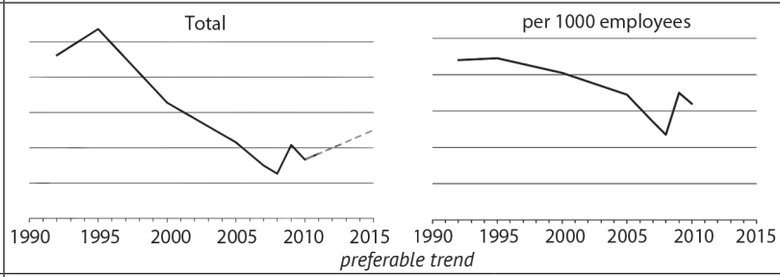
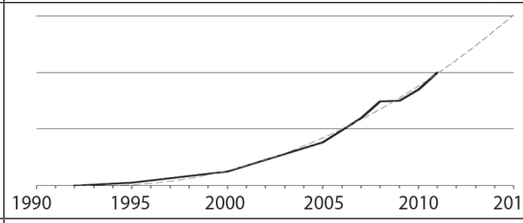
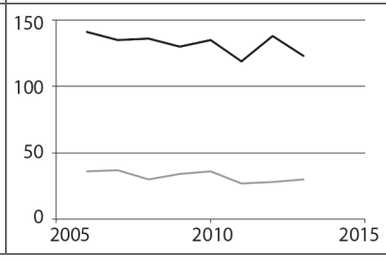
Category	Name of Indicators	Trends
Economy	Investments in technological innovations	 *Coke and oil, rubber and plastic products — preferable trends Products chemical industry — undesired trend*
Economy	Payments for allowable and excessive emissions (discharges) of pollutants (industrial and consumer waste)	 *preferable trend*
Economy	Investments in nature (fixed investment to environmental protection and rational use of natural resources)	 *preferable trend*
Society	The average number of people working at chemical plants	 *preferable trend*
Society	Average salary of people working at chemical plants	 *preferable trend*
Well-being	Fatal occupational incidents and occupational injuries with loss of ability to work for one day or more	 *preferable trend*

Table 2

Category	Name of Indicators	Trends
Well-being	Employees with occupational disease (intoxication) discovered for the first time	 *preferable trend*
Well-being	Consumption growth	 *preferable trend*
Well-being	"Dirty" cities – cities from "dirty priority list" (upper graph) and cities with high air pollution (lower graph)	 *no visible trends*

5. Diagram "the Cause-and-Effect Linkages among the Indicator

The stage S — Systems was aimed at the attempt to carry out a large-scale system analysis of the process of chemicals management in Russia in order to define key cause-effect relationships. We have analyzed the trends and come to the following conclusions:

- the chemical manufacturing process is vulnerable to economic factors (such as the crisis of 2008);
- there is a positive correlation between chemical production volumes and the amounts of pollutant emissions into the air, sewage discharge, production and consumption waste, the amount of injuries and occupational diseases (for example, almost all graphs reflect this correlation: increase in production of 2010–2011 is followed by simultaneous increase of adverse effects on humans and the environment);
- the correlation between manufacturing volumes and adverse effects is non-linear since some revenues are spent on nature;
- "dirty cities" (i.e., cities affected by high levels of pollution) are still the big concern. This indicator is important because currently about 60% of urban population (or 44% of the Russian population as a whole) comes through breathing polluted air.

In addition, it should be noted that:

- chemical pollution and the "dirty city" phenomenon is a contributing factor to relatively low life expectancy in Russia;
- the Russian economy is resource-based;
- a substantial portion of hazardous chemicals is exported (roughly 1/3 of all chemical products, not including the chemicals in articles);
- currently in Russia hazardous chemicals in products are not regulated or monitored

There are links between the indicators of chemicals management process represented in Figure 2. The indicator "chemicals volume" is selected as the central starting point for this analysis. The arrows show interrelations in the system, and specifically the influence of one indicator on another.

Then we identified the leverage points where innovations are likely to be the most effective, based on the system structure. Innovation within the process of chemicals management in Russia at a leverage point can produce the maximum effect, at minimal cost, due to system effects. Figure 2 demonstrates a positive (reinforcing) cycle involving production and consumption of chemicals. The increased consumption of chemicals causes an increase in their production, then the number of people working in the industry and their salary increases, that has an additional

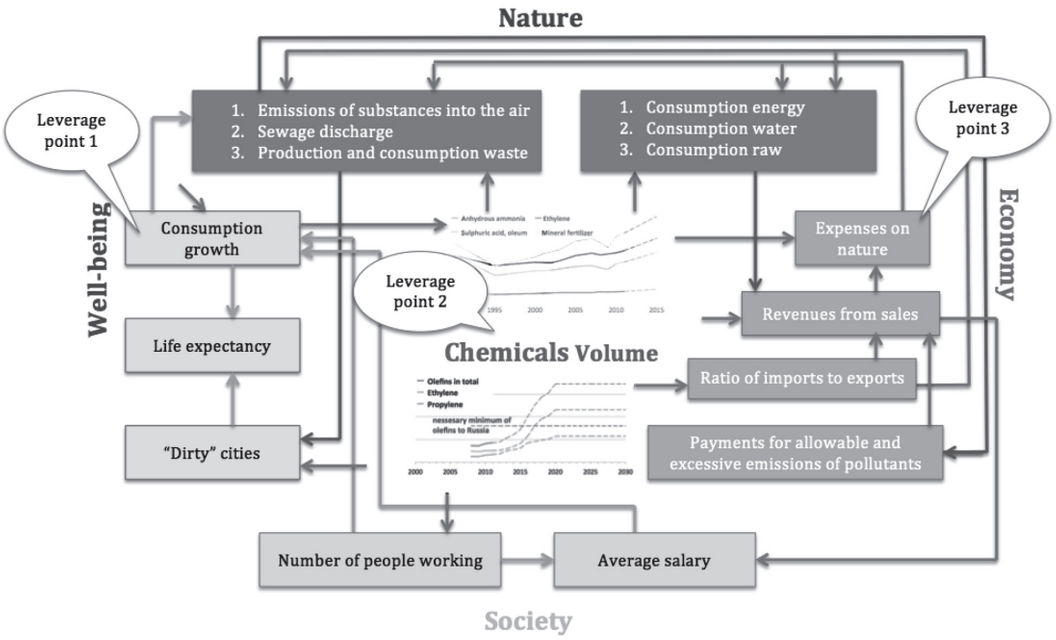


Figure 2. The System for the Process of Chemicals Management in Russia

positive effect on the consumption. This cycle, powered by a reinforcing feedback loop, adversely affects nature due to the increase of discharges, emissions and waste, and, as a consequence, adversely affects humans as well.

Leverage point 1.Innovation in chemical consumption (i.e., the consumers consciously choose products containing less hazardous chemical substances).

Leverage point 2. Reduction of risk levels and production volumes of hazardous chemicals. However, the Russian government considers an overall increase of chemicals production volume as one of its strategic goals.

Leverage point 3. Internalization of the "expenses" that accrue to nature and innovations in order to improve the quality of these economic incentives. By internalizing the expenses associated with damage to nature and humans, we can possibly establish another reinforcing cycle: qualitative and quantitative changes in management activities that will reduce, on the one hand, the costs for and consumption of energy, water and raw materials; and, on the other hand, promote a reduction in emissions and waste in order to reduce or avoid fees and penalties. These actions will increase innovation at the enterprise, leading to an increase in income of the enterprise and subsequently permitting more investment in environmental protection.

6. Identification of the Relevant Practices and the Analysis of the Best Practices

At the stage **I** — Innovations, we consider the potential best practices of chemicals management, and then choose those that can most effectively be implemented at the system leverage points.

We have analyzed the international experience and have chosen the following practices to review:

- the practice of informing all stakeholders, including the use of (Material) Safety Data Sheets ((M)SDS) and labelling
- the practice of risk assessment: Globally Harmonized System of Classification and Labelling of Chemicals (GHS), Global Product Strategy (GPS), OECD Decision and/or Recommendation for new and existing chemicals.
- the practice of state regulation: inventory of existing chemicals, lists of eliminated and restricted chemicals, authorization on usage and production
- self-regulation tools: systems of chemicals management, Responsible Care.

We have analyzed the selected practices and assessed their effectiveness at leverage points. We have estimated the current effectiveness of practices as well as their potential, their degree of implementation, problems hindering their full application, and the necessary changes in the application of practices. The results of the study are presented in Table 3.

The analysis showed that sustainable management of chemicals in Russia today would most effectively consist of:

- the creation of the legal framework, including legislative support for many existing best practices;
- the involvement of chemicals businesses and the general public in the process of promoting management, including creation of a culture of consumption and production of sustainable chemicals;

Table 3

The Results of the Analysis of the Effectiveness of Selected Best Practices

№	Best practices	Effectiveness in leverage points						Degree of implementation (documents)	Problems hindering full use of the practice	Necessary changes in the use of practices
		Existing			Potential					
		1	2	3	1	2	3			
1	(M)SDS	±	–	±	+	+	+	A number of enterprises that use (standard)	Voluntary using. Not all enterprises are developing. Access is limited	Chemical safety law. Information system for all stakeholders
2	Labelling	–	–	–	+	–	–	Applied by some enterprises (standard)	Voluntary using. Difficulty of using in practice	Chemical safety law. Lists of labeled chemicals. Guidance. Education.
3	GHS	–	–	–	+	+	+	Almost never used (system standard)	Voluntary using. Difficulty of using in practice	Chemical safety law. Lists of classified chemicals. Guidance. Education.
4	GPS	–	–	–	+	+	+	Not using	Poor motivation for business	Motivation of business, involvement of society, state support
5	OECD Decision/ Recommendation for new and existing chemicals	–	–	–	+	+	+	Not applied fully	No regulatory documents	Development of the regulatory documents
6	Inventory of existing chemicals	–	±	±	+	+	+	Russian Substance Inventory contains more than 4000 chemicals (decision on registration)	Not all hazardous chemicals are included. No data on export volume of chemicals	Regulatory requirements to be included in the list of all imported / produced hazardous chemicals (including those in products)
7	List of eliminated and restricted chemicals	±	+	–	+	+	–	The main conventions on safety of chemicals are ratified	The difficulties with the control and disposal of existing chemicals	Control of imported chemicals in products. Control of chemicals "from cradle to grave".
8	Authorization on using and production	±	±	–	+	+	–	Applies to certain types of chemicals (law and decision)	There is no common approach. Different approaches to risk assessment	Implementation of GHS. The use of decisions / recommendations OECD
9	Management systems	–	–	±	+	+	+	Used by many enterprises (standard)	Formal use. Are not used as a tool for regulation	Motivation of business, involvement of society, state support
10	Responsible Care	–	–	±	+	+	+	Applied at individual enterprises	Low% participation among businesses. Poor motivation	Motivation of business, involvement of society, state support

«–» not effective, «±» don't using all possibilities, «+» effective

- in addition to the state regulation, the implementation of business initiatives and the tools of self-regulation for business

7. Strategy for the Advancement of Sustainable Management of Chemicals

The last step S — Strategy is the construction of a general strategy for the advancement of sustainable management of chemicals. For this purpose, TSIS uses a technique called "Amoeba." The "Amoeba" is a model of a society in need of innovative solutions and approaches, but also including stakeholders who view such innovation with great suspicion and caution. The main category roles in a social "Amoeba" are "innovators" — those who create innovative solutions and approaches; "change agents" — those who initiate the activity of selection and implementation of these solutions; "transformers" — those who make the decision about the adoption of innovation for society; "mainstreamers" — those who are ready to adopt the innovation only after its approval by the transformer; and "laggard" — those who follow the rest eventually, but with a certain reluctance and delay caused by conservative thinking.

If you transfer this model to the Russian community in relation to sustainable management of chemicals, then the role of "innovator" is taken by the Russian scientific community or the international community (through the adoption of international documents — conventions, declarations, programs and action plans); or innovation can even occur at the country or company level. The role of the change agent can be taken by various unions and associations (such as Russian Chemists Union, Russian Union of Industrialists and Entrepreneurs) or research institutes, who collectively promote innovations of the type identified above. The transformer in this Amoeba is traditionally the Russian state. The roles of mainstreamers and laggards are usually performed by a number of business representatives and government officials.

8. Conclusions

As a result of TSIS analysis, we have determined that the creation of sustainable management of chemicals in Russia will require changes in chemical production (including internalizing the expenses now externalized to nature) and the consumption chains. The time to act is now, otherwise the planned increase in production and consumption of chemicals is very likely to lead to catastrophic consequences both for the

nature and for the human health. For the most part, the best practices in sustainable management of chemicals (practices that could have a positive impact on the situation) are known in Russia. However, their effectiveness is low. The situation reflects the absence of a Russian legal framework on chemicals safety, and the current low motivation of business to adopt such practices in the absence of clear signals that it should do so. In order to create chemicals management system, the Russian Government should not use only state regulation, but also actively promote and develop business initiatives and involve society.

Acknowledgments

This work was performed within the framework of the project task No. 5.2598.2014/K with the support from the Ministry of Education and Science of the Russian Federation and was supported by the Ministry of Education and Science within the framework of basic component of the State Assignment.

REFERENCES

1. *Rockström J., Steffen W., Noone K.* A safe operating space for humanity. Nature. 2009, I. 461, pp. 472–475.
2. Available at: http://sustainabledevelopment.un.org/ (Accessed 06 November 2014).
3. 2011/SOM3/CD/018. Strategic Framework for Chemicals in the Asia Pacific Region.APEC Chemical Dialogue September 13, 2011. Available at: http://mddb.apec.org/documents/2011/CDSG/CD/11_cd_018.pdf (Accessed 06 November 2014)
4. 2012/SOM1/CDSG/014. Principles for Best Practice Chemical Regulation. APEC Chemical Dialogue May 22, 2008. HUUwww.apec.org/.../B5821A4C2FCA4685A6192.../UUH (Accessed 06 November 2014)
5. Development strategy for Russian chemical and petrochemical industry until 2015. Approved by the order № 119 of the Ministry of Energy of the Russian Federation, March 14, 2008.
6. Development plan for Russian gas- and petrochemistry for the period until 2030. Approved by the order №79 of the Ministry of Energy of the Russian Federation, March 1, 2012.
7. *AtKisson A.* The Sustainability Transformation. How to Accelerate Positive Change in Challenging Times. Published November 19th 2010 by Earthscan Publications. P. 323. ISBN 1849712441

Устойчивое обращение химических веществ в России — увеличение использования при снижении уровня воздействия

А. Аткиссон, старший научный сотрудник, Центр устойчивого развития, Университет Упсала, Швеция
А.С. Макарова, ведущий научный сотрудник, кандидат технических наук, Российский химико-технологический университет имени Д.И. Менделеева
Н.П. Тарасова, директор Института химии и проблем устойчивого развития, чл.-корр. Российской академии наук, доктор хим. наук, профессор, Российский химико-технологический университет имени Д.И. Менделеева
С.В. Макаров, доцент, кандидат технических наук, доцент, Российский химико-технологический университет имени Д.И.Менделеева

В статье анализируется обращение химических веществ в Российской Федерации. Мы использовали метод TSIS в качестве инструмента анализа и оценки устойчивого обращения химических веществ в России. Проведенный анализ показал, что для устойчивого обращения химической продукции необходимо:
- *создать нормативно-правовую базу, в том числе законодательную поддержку многих существующих инициатив;*
- *привлечь к решению проблемы безопасного обращения химических веществ бизнес и общественность, в том числе с целью создать культуру производства и потребления химикатов;*
- *помимо государственного регулирования использовать инициативы бизнеса и инструменты саморегулирования.*

Определено, что для создания в РФ устойчивого обращения химических веществ необходимо изменить отношение к производству (в том числе в части природоохранных мероприятий) и потреблению химических веществ. Действовать надо уже сегодня, иначе запланированный рост производства и потребления химических веществ приведет к катастрофическим последствиям для природы и человека. Для воздействия в выбранных точках на основе анализа международного опыта составлен перечень лучших практик. Большинство этих практик известно в России, но эффективность их использования низкая, что обусловлено отсутствием в РФ единой законодательной базы в области безопасного обращения химических веществ и низкой мотивацией бизнеса.

Ключевые слова: устойчивое развитие, химические вещества, окружающая среда, риск.