

## SUSTAINABLE DEVELOPMENT, CLEAN TECHNOLOGY AND KNOWLEDGE FROM INDUSTRY

by

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*Clean technology or clean production is the most important factor for the economic growth of a society and it will play the main role not only in the area of cleaner production, but also in sustainable development. The development of clean technology will be the main factor of the company's strategy in the future. Each company, which wants to reach the competitive position at the market and wants to be environmentally friendly, has to accept the new approach in corporate management and the strategy of new clean technology. The main principles of clean technology are based on the concept of maximum resource and energy productivity and virtually no waste.*

*This approach may be limited by human resources and the level of their environmental knowledge. Companies are committed to the development of the workers' skills, and thus to the improvement of the company for the full implementation of the environmental legislation and clean production concept.*

*Based on this commitment, one of Tempus projects is designed to improve the university-enterprise cooperation in the process of creating sustainable industry in Serbia, Bosnia and Herzegovina and the Former Yugoslav Republic of Macedonia.*

*To achieve this goal, partner universities will create special courses on sustainable industry and thus enhance the lifelong learning process and cooperation between industry and universities in the Western Balkan countries.*

Key words: *sustainable development, clean technology, environmental knowledge*

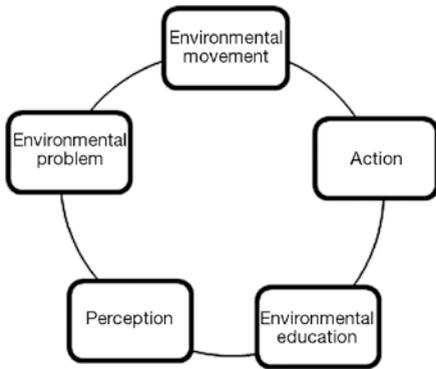
### Introduction

At the end of the 90's, the knowledge and responsibility of various social groups on global environmental problems was the subject of numerous studies [1-7]. The importance of education on the sustainability potential can be seen in fig. 1.

The study at the Iranian University about environmental knowledge of students of medicine in respect of the disposal of solid wastes shows that 66% of 237 interviewed students do not have any activities in segregation and recycling of solid wastes [8].

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Using cluster sampling method, some authors have studied correlation of energy consumption and environmental attitude and environmental behavior of citizens in some Iranian cities. The results show that there is no significant relationship between environmental knowledge and energy consumption behavior [9].



**Figure 1. Scheme of sustainability potential**

The comparison of environmental behaviour between students of business in Chile and USA (666 tested students) and the assessment of three theories show that variable norms produce the strongest relation towards environmental behaviour [10].

The Spanish researchers have investigated the influence of environmental knowledge on organizational output in 127 hospitality companies. The results show that environmental knowledge is important element for developing organizational output [11].

The implementation of environmental best practice (best available technologies – BAT, pollution prevention technologies and early timing environmental strategies) increases cost advantages relative to major competitors. Cost advantages are the company's capabilities to capture profits by implementing three mentioned best practices [12].

The Second Minnesota Report Card on Environmental Literacy [3] is the typical example of the level of knowledge assessed concerning environmental problems in Minnesota State.

In this paper, we have studied the level of knowledge of employees in industry. The survey is done in 13 companies located in three Ex-Yugoslavian countries: Serbia, Bosnia and Herzegovina and Former Yugoslav Republic of Macedonia. The most of the companies are from pharmaceutical (five) and from food (four) industry. Three companies deal with inorganic technologies and metallurgy. One company deals with the production of lubricants and industrial oils. Mentioned companies have more than 1000 employees. The survey covers over 100 employees who are directly responsible for production, control and environmental protection.

### The structure of the questionnaire

In order to get objective information on the level of knowledge of employees from industry, three types of questionnaires are created. The first questionnaire covers questions concerning the company's management system, tab. 1. The scope of this questionnaire is to get information about exiting environmental management in the company. The second questionnaire consists of questions focusing on technical and technological details important for the production process, tab. 2, which gives insight into the degree of industrial modernity. The third and the most important questionnaire consists of questions concerning sustainability, tab. 3. This third questionnaire is the basis for assessing the level of knowledge and it is the focus of our paper.

### Data evaluation

The aim of the first and the second questionnaire is to provide necessary information about the company and its technological processes and as such they are not scored. The third

questionnaire is a test on environmental knowledge of industrial employees and therefore it is scored. This questionnaire consists of 33 questions, which are divided into six sets. Every question carries certain number of points as shown in tab. 3. The total score is 245, while each set of questions carries this proportion of the total score:

- (1) general environmental knowledge 20.41%,
- (2) sustainable development 14.29%,
- (3) pollution prevention and waste management 28.57%,
- (4) environmental institutions 10.20%,
- (5) environmental management tools 20.41%, and
- (6) renewable energy 6.12%.

**Table 1. Basic data about the company**

Basic data about the company	
Name of the company	
Address	
Activities	
Number of employees	
Main products	
Main customers	
Institutions with which the company had the agreement on cooperation for environmental protection	
Health, safety, environment, and quality system – HSEQ system	
Is there an integrated system of management in the company?	
Is there a HSEQ system in the company?	
Is there a vertical HSEQ organizational system in the company?	
Give the HSEQ organizational chart	
Give the qualification structure of every HSEQ organizational unit	
Give the description of jobs in every HSEQ organizational unit	
Give titles of documents which define HSEQ jobs and the organizational structure	
Health, Safety and Environment System – HSE System	
Is there HSE organizational system in the company?	
Is there vertical HSE organizational system in the company?	
Give the organizational structure of HSE	
Give the qualification structure of every HSE organizational unit	
Give the description of the jobs in every HSE organizational unit	
Give titles of documents which define HSE jobs and organizational structure	
Organizational structure and environmental protection	
Give organizational chart of the company	
Give qualification structure of every organizational unit	
Give jobs description in every organizational unit	
Give titles of documents which define environmental protection jobs and organizational structure	

**Table 2. The company's technological data**

Description of technology	Description of technology
	Raw material mass balance and their ecological features Consumption of energy, water and chemicals
Waste streams	Waste gases
	Waste water
	Waste packaging
Monitoring and accidents	Monitoring program
	Accidents
	Sanitation of accidents

**Table 3. Questionnaire of environmental knowledge**

Test	Points
<i>General environmental knowledge</i>	
1. What are global problems environment?	5
2. What is greenhouse effect?	5
3. What is GHG?	5
4. What is the cause of acid rains?	5
5. Indicate one millenium goal.	10
6. What are the millenium goals?	20
<i>Sustainable development</i>	
7. Definition of sustainable development?	5
8. What is OUR COMMON FUTURE?	5
9. What is Rio declaration?	5
10. What is Agenda 21?	5
11. Does Serbia have the strategy for sustainable development?	5
12. State two indicators of sustainable development.	10
<i>Pollution prevention and waste management</i>	
13. What is Basel convention?	5
14. What is IPPC?	10
15. What is BREF?	15
16. What wastes does your company generate?	5
17. What is BAT?	15
18. Is there a method for waste treatment in your company?	5
19. What is the difference between municipal and industrial waste?	5
20. What is remediation?	5
21. State two methods for waste water treatment	5
<i>Environmental institutions</i>	
22. What is DG environment?	15
23. State ate least three environmental agencies?	5
24. What is the difference between EPA and UNEP?	5
<i>Environmental management methods</i>	
25. What is standard 14001?	5
26. Basic features of the 14001 standard	10
27. What is EMAS?	5
28. What is the difference between EMAS and ISO 14000 standard?	20
29. What is environmental impact assessment?	5
30. What is LCA?	5
<i>Renewable energy</i>	
31. What is the difference between renewable and non-renewable energy sources?	5
32. State three renewable energy sources.	5
33. What is biodiesel?	5
TOTAL POINTS	245

Correct answers gained maximum points per question, while incomplete and false answers gained null points.

Maximum total score which one company can achieve is the number of filled questionnaires multiplied by total score for one filled questionnaire (245 points). Obtained score per company is the sum of achieved points and it is shown as the percent of maximum possible score.

The analysis is done for overall test results as well as for main sets of questions. The analysis done for sets of questions is shown as the percent of maximum possible score per relevant set of questions.

Detailed analysis is done for two companies. The evaluation of all six sets of questions is given, pointing out the question with the highest and the question with the lowest achieved score. Obtained points are given as the percent of maximum possible score. The results are shown in tables and in diagrams.

## Results and discussion

### Main results

The results of tests in 13 companies show a wide variety of knowledge, from very high (97%) to very low level (19%). The obtained results for all companies can be seen in fig. 2.

The highest results are obtained in companies which have implemented the integrated system of management (E and G companies). The score of 50% is obtained in companies which have environmental protection organizational units (companies M, F and C). The score below 30% is achieved in companies (B, D and I) where there is no environmental management group in the corporate scheme.

Concerning the set of questions on general environmental knowledge, the average value of obtained results is 48.05%. The following results for each company are given in fig. 3.

It is interesting that the level of general environmental knowledge is independent of the of the tested staff's level of education. However, it is correlated with the level of environmental management system in the company. The companies with achieved high level of knowledge have clear environment program in practice. The relatively low level of knowledge in some companies indicates the necessity to create an introduction course oriented to basic knowledge on environment issues.

Concerning understanding of sustainable development issues the following results are obtained, fig. 4.

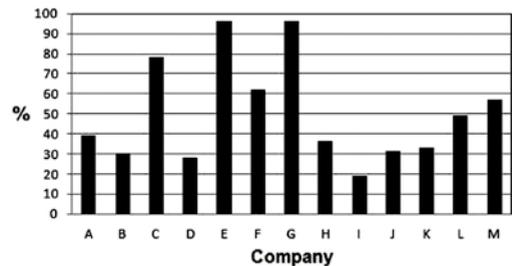


Figure 2. Overall test results

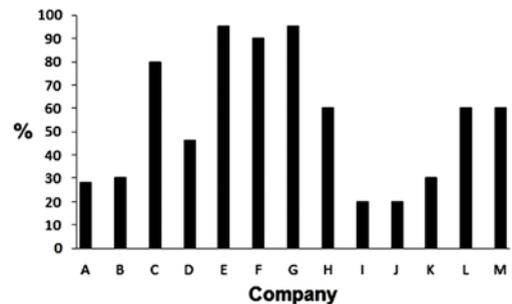


Figure 3. Test results on general environmental knowledge

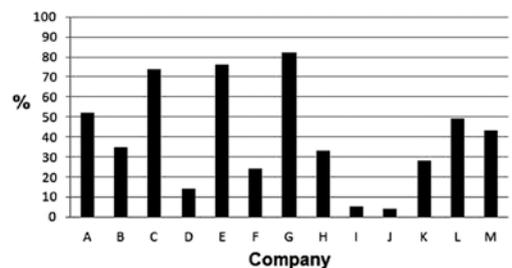
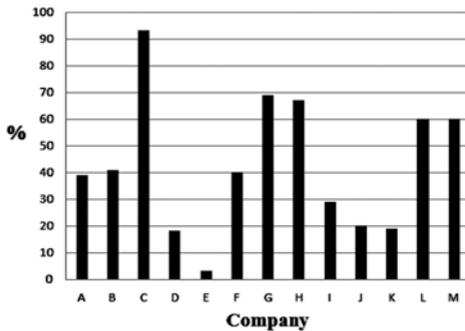
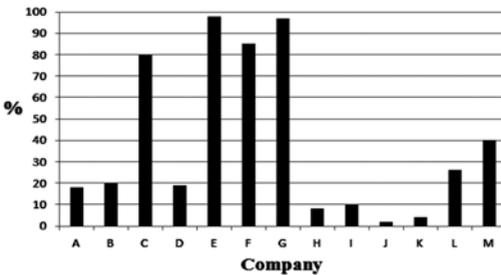


Figure 4. Test results on sustainable development knowledge



**Figure 5. Test results on pollution prevention and waste management knowledge**



**Figure 6. Test results on environmental management methods**

While the level of knowledge on ISO 14000 standard is acceptable (above 65%), the level of knowledge on LCA method is unknown to 85% of tested employees in the companies.

### **Detailed analyses for companies A and B**

#### *Company A*

In this company, 24 employees with higher education are tested. Out of maximum 5880 points, 2305 is achieved (39% of average value). The obtained test results are given in tab. 4.

Tested employees have a very good knowledge concerning renewable energy sources (66% of maximum points). The weakest knowledge (17% of maximum points) refers to the set of questions on environmental management methods.

#### *Company B*

The same number of employees is tested in Company B as in Company A. Tested employees have higher education. Obtained score in the test is 1890 or 32% out of total 5880 points.

If companies E and G with high level of knowledge in this analysis are excluded, the sustainable development issue is unknown in more than 80% of remaining companies.

In two companies, there are no answers on the question No. 7, tab. 3.

The level of knowledge concerning pollution prevention and waste management in 60% of investigated companies is below 50%, fig. 5.

For example, Integrated Pollution and Prevention Control – IPPC directive (question No.14) is unknown in 11 companies. Moreover, the IPPC directive which includes the procedure for obtaining integrated license is also unknown, even in companies which have in their organizational structure some environmental protection units.

Test results concerning environmental management methods (ISO 14000 Standard, Environmental Impact Assessment – EIA and Life Cycle Analysis – LCA) show that the level of knowledge is rather low (36.9% average value). The detailed results are given in fig. 6.

**Table 4. Company A – Test results**

Questions	Obtained score [%]
Set of questions on general environmental knowledge	52
Set of questions on sustainable development	28
Set of questions on pollution prevention and waste management	39
Set of questions on environmental management methods	17
Set of questions on environmental institutions	26
Set of questions on renewable energy	66

**Table 5. Company B – Test results**

Questions	Obtained score [%]
Set of questions on general environmental knowledge	35
Set of questions on sustainable development	28
Set of questions on pollution prevention and waste management	44
Set of questions on environmental management methods	24
Set of questions on environmental institutions	17
Set of questions on renewable energy	47

It is interesting to note that the employees have the best knowledge about renewable energy sources (47% of total points). Minimum points are achieved for questions concerning environmental agencies and institutions (17% of total points). The scheme of the overall test data in companies A and B is given in fig. 7.

*General environmental knowledge*

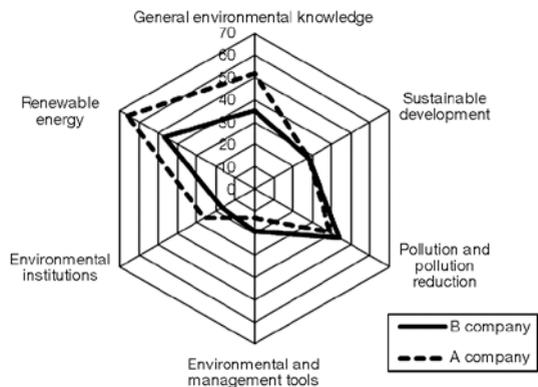
The best knowledge in Company A refers to general knowledge about the environment (76% of total points). In Company B, maximum achieved points correspond with questions concerning millennium goals (49 % out of total). It should be pointed out that the majority of tested staff indicates the poverty as the most important millennium goal.

*Sustainable development*

The majority of the points are obtained for the question No. 11: *Does Serbia have the strategy for sustainable development?* Comparing the results, the number of positive answers differs highly. In Company A, the obtained points to this question are 84%, while in Company B, 53% of total points. In both companies, obtained points for the question No. 12: *Give two indicators of sustainable development* are rather low. Company A obtained 4% while Company B obtained 8% of total points for this question.

*Pollution prevention and waste management*

The level of knowledge relevant to these environmental issues in Company A is rather high (over 82%), while in Company B, it is 55%. Answers to the question No. 18: *Is there a*



**Figure 7. Overall test results (companies A and B)**

*method for waste treatment in your company?* achieved high score in companies (80% in Company A and 87% in Company B).

Unfortunately, the knowledge about generated wastes in the companies (question No. 16) is rather weak. This indicates that the actual knowledge on this set of question is weaker. This conclusion can be confirmed by the very low score concerning BAT (14% in Company A) and knowledge concerning remediation (29% in Company B).

### *Environmental protection methods of analysis and management*

The majority of positive answers are given to the question No. 15: *What is ISO 14001 standard?* In Company A, the score of 83% is achieved, while in Company B, it is 43.5%. Minimum points are obtained for the question No. 30: *What is LCA?* In Company B, the minimum knowledge corresponds to environmental impact assessment (16%). Obtained results indicate that the level of knowledge concerning the assessment of technological processes and products impact on the environment is not known to the majority of tested staff.

### *Environmental institutions*

Environmental institutions are rather unknown to tested employees. Just 10% of them in Company A were able to indicate 3 institutions. In Company B, the results are slightly better (15%).

### *Renewable energy sources*

Rather high score is achieved to the question No. 32: *Indicate at least 3 renewable energy sources* (87% in both companies). It is surprising that very low score is obtained for the question No. 33: *What is euro diesel?* (15% in Company A). In Company B, just few tested employees (three of them) had correct answer to the question No. 31: *What is the difference between renewable and non renewable energy sources?*

## **Conclusions**

- Obtained results in tests show a wide variety of knowledge from very high to very low level.
- The best results are obtained in companies which have integrated management system
- The type of the company's main activity does not have any influence on obtained results
- Far less knowledge in all companies refers to IPPC directive, EIA, LCA, etc.
- In all companies, the weakest knowledge concerns pollution prevention and waste management issues
- Obtained results indicate the need of an introductory course oriented to the basic knowledge on environmental issues.

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## References

- [1] Sudarmadi, S., Suzuki, S., Kawada, T., Netti, H., Soemantri, S. Tritugaswati, A., A Survey of Perception, Knowledge, Awareness and Altitude in Regard to Environmental Problem in Jakarta, Indonesia, *Environment, Development and Sustainability*, 3 (2001), 2, pp. 169-183
- [2] Bradley, J., Environmental Knowledge, Environmental Attitudes, and Vehicle Ownership and Use, Dissertation, University of California, Berkeley, Call., USA, 2006
- [3] Block, L., A Survey of Environmental Knowledge, Attitudes and Behaviour of High Schools Students in Soweto, Johannesburg, South Africa, [www.geog.tamu.edu/sarah/blockschoeman3.pdf](http://www.geog.tamu.edu/sarah/blockschoeman3.pdf)
- [4] Meinhold, J. J., Amy, J., Malkus, A. J., Adolescent Environmental Behaviors: Can Knowledge, Attitudes, and Self-Efficacy Make a Difference, *Environment and Behavior*, 37 (2005), 4, pp. 511-532
- [5] Davidson, S., Martin, C., Steven, T. S., Mori, I., Scottish Environmental Attitudes and Behaviors Survey 2008, Scottish Government Social Research <http://www.scotland.gov.uk/Resource/Doc/280711/0084578.pdf>
- [6] Gambro, J. S., Switzky, H. N., A Survey of Environmental Knowledge in High School Students: Levels of Knowledge and Related Variables, [www.eric.ed.gov](http://www.eric.ed.gov) 2010
- [7] Murphy, P. T., Minnesota Report Card on Environmental Literacy, Minnesota Office of Environmental Assistance, [www.seek.state.mn.us/publications/reportcard2008.pdf](http://www.seek.state.mn.us/publications/reportcard2008.pdf), (accessed: April, 2010)
- [8] Ehrampoush, M. H., Baghiani Moghadam, M. H., Survey of Knowledge, Attitude and Practice of Yazd University of Medical Sciences Students about Solid Wastes Disposal and Recycling, *Iranian Journal of Environmental Health Science & Engineering*, 2 (2005), 2, pp. 26-30
- [9] Maleki, A., Karimzadeh, S., A Survey of Relationship between the Environmental Attitudes and Environmental Knowledge and Energy Consumption Behavior among Citizens of Urmia, West Azerbaijan, Iran, *International Journal of Social Sciences and Humanity Studies*, 3 (2011), 1, pp. 1309-8063
- [10] Scherer, F. R., Pradena, L., Parada, V., A Cross-Cultural Assessment of Three Theories of Pro-Environmental Behavior: A Comparison between Business Students of Chile and the United States, *Environment and Behavior*, 43 (2011), 5, pp. 634-657
- [11] Cegarra-Navarro, J. G., Martinez Martinez, A. M., Managing Environmental Knowledge through Learning Processes in Spanish Hospitality Companies, *The Spanish Journal of Psychology*, 13 (2010), 2, pp. 827-840
- [12] Christmann, P., Effects of Best Practices of Environmental Management on Cost Advantage: The Role of Complementary Assets, *Academy of Management Journal*, 43 (2000), 4, pp. 663-680