Prof. RNDR. Bohuslav Sekerka, CSc.

Bítovská 1213
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Prague, March 10th, 2016

Doctoral Dissertation

Plastic Waste Management in Ghana:
A Theoretical Framework for Sachet Water Waste Recovery Scheme
Through Extended Producer Responsibility

by

Ing Ebo Tawiath Quartery

Opponent's Review

The doctoral work consists of the introduction and eight chapters. Individual chapters consist of paragraphs. The chapters can be seen from the following overview:

Introduction
1. Evolution of solid waste management
2. Research design & methodology
3. Plastics and plastic waste management
4. Extended producer responsibility (EPR) and waste management
5. Theoretical conceptualization of an EPR scheme for plastic waste management in Ghana; case of sachet water waste
6. Analysis - prospects of the EPR program implementation in the sachet water industry in Ghana
7. Results of analyses and discussion
8. Conclusions and benefits of the thesis

Solid waste management (SWM) is a problem in in many developing economies as in Ghana. Doctoral Disertation focused on this area.

Unfortunately, they were not taken into account the other Ghana´s economic sectors and products where the problem waste management occurs, too.

I believe that a brief description of the economic potential of Ghana would provide deeper insight into the problems of pollution in Ghana. Therefore I mention a short surway of Ghana economics.

Ghana is one of the countries on the Africa continent that produces petroleum and natural gas, with the continent's fifth largest oil reserves and sixth largest natural gas reserves. Ghana is one of the world's largest gold and diamond producers, and is projected to be the largest producer of cocoa in the world. Ghana's growing economic prosperity and democratic

political system has made it a regional power in West Africa. It has27.0 million inhabiting population.

There are different kinds of plastics waste generated in Ghana but the predominant type is the High Density Polyethylene (HDPE) resin, a recyclable plastic, used to produce bottles for milk and other beverages. A typical example of this type of plastic in Ghana is the sachet water packaging. The sachet water industry is a major contributor to plastic waste production in Ghana, accounting for, by estimation, approximately 40% of the plastic waste produced in Ghana. With this threat of sachet waste in mind the purpose of this study is to exploring the role Extended Producer Responsibility (EPR) can play in waste management in Ghana. The study proposes a national action plan with corresponding policies to shift the burden of management of plastic waste, specifically sachet waste to producers.

The problem is, how to force the manufacturer to do it. This policy is shrinking their profits and therefore do not accept it voluntarily. This is related to the adoption of this policy by the state or regional authorities in the form of laws and regulations. I'd like to know author´s opinion.

The scope of study is divided into four folds.

- The first scope is a review of literature to get a better understanding of evolution of SWM and the current situation in Ghana.
- The second part deals more with the theme of plastics and plastic waste management strategies, with the processes that are taking place within the socio-economic sphere of recycling activities in Ghana.
- Third part narrows down the theme further to sachet waste where the packaged water industry and its environmental impacts from the use of their products.
- Then the fourth part analyses the concept of EPR with its policy implementation and how this information gathered can be used to improve recycling activities for plastic waste in Ghana.

The study uses selected analytical frameworks to identify and evaluate the challenges and opportunities in producer involvement in management of their products at the end of life. This study also applies industrial ecology and eco-efficiency paradigms involving multidisciplinary approach, spanning the fields of producer responsibility, product stewardship and social studies.

Doctoral student selected range of problems comprehensively describes. His interpretation is understandable. At the same he uses his knowledge of other countries (South Africa, and German Federal Republic).

If the work will be published as a book, I recommend integrate hypotheses which have to be defined and answered into that book. At the current presentation should also be mentioned hypotheses and commented their performance.

Probably with regard to the unavailability of data on such partial problem that is solved by a PhD student, are not included in the models and theirs solutions. Projects of similar nature and require different kinds of aspects: personnel, technical, informational, financial, etc. These problems are not considered in the doctoral dissertation.

The submitted doctoral dissertation meets the requirements placed on them, and therefore, after successfully defending, I propose to grant the degree of Doctor of Philosophy (in brief PhD) to doctoral student Ing. Ebo Tawiath Quarter.

EXPERT OPINION

on the doctoral thesis entitled

Plastic Waste Management in Ghana: A Theoretical Framework for Sachet Water Waste Recovery Scheme through Extended Producer Responsibility

Author of thesis: Ing. Ebo Tawiah Quartey

The Ph. D. thesis of Ebo Tawiah Quartey focuses on some aspects of the solid waste management system in Ghana with a special attention paid to plastic waste from the packaged water industry. A national action plan for the management of these wastes is proposed in this dissertation.

In the introductory part of his thesis, the author summarizes the existing concepts and trends in the solid waste management, describes the solid waste management systems in Ghana and gives some comparison with the waste management system in the Czech Republic. Specific problems of the plastic waste management in the packaged water industry are discussed in the following part of the thesis together with related socio-economic aspects and possible environmental impacts.

In the key parts of his thesis, the author analyses possible strategies for further development in solid waste management systems. The concept of Extended Producer Responsibility (EPR) was identified as an effective tool for improving the effectiveness of the waste management system and various modes of its implementation are mentioned. The dissertation involves a comprehensive analysis of the situation in Ghana and an insightful discussion of possible benefits related to the implementation of the EPR scheme in developing countries.

The structure of thesis corresponds with the objectives of the work and follows prescribed standards of doctoral dissertations. There are some minor imperfections in the terminology (recycling vs. removing) in the third part of the work; however they do not have any significant impact upon intelligibility of the work itself. The strong point of the work is a personal engagement of the author in the examined problems. The author proved an ability to analyse the problems of solid waste management in their complexity, as well as an ability to generalize the obtained findings and to make reasonable conclusions.

Conclusions:

Based on the submitted dissertation I declare that Ing. Ebo Tawiah Quartey demonstrated a creative ability and his work meets the requirements for the doctoral thesis in the field, and therefore I recommend it for defence.

Ústí nad Labem, March 26, 2016

prof. Ing. Pavel Janoš, CSc.
Faculty of Environment
University of J. E. Purkyně in Ústí nad Labem

Assessment of the Ph.D. thesis
Title of thesis: Plastic Waste Management in Ghana: A Theoretical Framework for Sachet Water Waste Recovery Scheme through Extended Producer Responsibility
Author: Ebo Tawiah Quartey

The Ph.D. thesis completed by Ebo Tawiah Quartey refers generally to the field of waste management strategies applicable to effective collection and treatment of specific type of plastic waste in Ghana. The text is, in particular, focused to the concept of Extended Producer Responsibility (EPR) which is related to a polyethylene based package material for drinking water distribution. A set of recommendations and proposals towards the national waste management system is formulated in the final part of the text. When driving his Ph.D. thesis to the above stated topic Ebo Tawiah Quartey decided to face a complicated and complex problem with high environmental and social importance.

The theoretical background of thesis consists of 1) comprehensive description of the solid waste management principles and hierarchy (with special attention to Ghana and Czech Republic), 2) systematic review to production of polymer materials and plastic waste management, and 3) introduction into the concept of Extended Producer Responsibility. The theoretical part of thesis is very extensive, well arranged and supported by almost 200 references, which clearly demonstrate deep and long-termed study within available information sources.

The analytical part of thesis tries to examine the applicability of the EPR concept within the waste management system in Ghana to facilitate plastic waste recycling and to reduce environmental damage caused by currently unacceptable collection of drinking water package plastic bags.

Following from the above stated facts I can confirm, that the Ph.D. thesis completed by Ebo Tawiah Quartey presents an original and valuable contribution to the field of solid waste management, both in national and global level. The theoretical background, research methodology and analysis, as well as final conclusions and recommendations formulated within the text are clearly defined and interconnected. The total extent of the Ph.D. thesis is quite satisfactory for the final document of the Ph.D. study program. All the text is written in excellent English with only few exceptional misprints (for example page 60, second paragraph - "*molecular weights of plastic may vary from about 20 000 to 100 000 mg/L*").

A few questions to discussion may be formulated as follows:

- It seems that most of the environmental impacts following from uncontrolled plastic waste rejection in Ghana (rivers contamination, accumulation in drainage channels) would mainly be reduced through functional collection system. Further and/or final treatment of collected waste might be less important and even the low priority - but affordable - landfill (of course sanitary) would bring a big progress compared to simple dumping. What is the exact role of the Ministry of Environment and Science in the system of waste collection? Are there any obligatory national directives for municipal waste collection? If I understand correctly, the solid waste management in Ghana is under the responsibility of local governments, which indicates possible differences through the country.

- The thesis compares (in theoretical part) the waste management systems in Ghana and Czech Republic. Was there possibly any attempt in Ghana to organize the separated collection of municipal waste components through state-supported monopolized subject? (See EKO-KOM for the Czech Republic).

- Ghana is a member state of the Commonwealth, is there any professional or economical help within the environmental issues from the other members?

Finally I would like to emphasize that the thesis submitted, according to my personal judgement, fully satisfied all the demands required for the final report of the Ph.D. study program.

Namely:

- the thesis presents an original and extensive work of high scientific quality and of indisputable practical importance
- the author proved his ability to independently formulate, manage, complete and publish the extensive scientific project (obviously the knowledge from many different fields had to be combined)
- the thesis has comprehensive character, which clearly drives a reader from introductory definition of the problem to the final conclusions

Based on the above stated it is a great pleasure to me to recommend the Ph.D. thesis of Ebo Tawiah Quartey to the defence.

In Prague 16. 3. 2016

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February 22, 2016

OPINION OF THE SUPERVISING DEPARTMENT ON THE DISSERTATION

Ing. Ebo Tawiah Quartey was admitted to full-time studies in the doctoral study program "Chemical and Process Engineering" study field "Environmental Engineering" at the Institute of Environmental and Chemical Engineering, Faculty of Chemical Technology, University of Pardubice in the 2010/2011 academic year. He completed all courses required by the test plan, the state doctoral examination he performed on September 11, 2013 (subjects: Selected Problems of Environmental Economics, Modern Methods of Waste Disposal, and Advanced Environmental Technologies).

The dissertation deals with the system as the collection and sorting of waste from bottled drinking water in Ghana. The extension of producer responsibility and eco-efficiency as a conceptual framework was chosen. The thesis elaborated the concept of enhanced responsibility and its implementation, and used selected analytical framework for identifying and evaluating the challenges and opportunities in the manufacturer's participation in waste management.

Ing. Ebo Tawiah Quartey fulfilled during his studies in a doctoral program all the requirements of the study plan and demonstrated ability for independent scientific work also in the fact that he participated in the publication of the results in peer-reviewed journals (1 article in a journal mentioned in the Web of Science database, 2 articles in peer-reviewed journals included in Scopus), as well as contributions to conferences, respectively in their proceedings. Based on the above facts, I recommend the submitted dissertation titled "*Plastic Waste Management in Ghana: A Theoretical Framework for Sachet Water Waste Recovery Scheme through Extended Producer Responsibility*" for the defence.

prof. Ing. Petr Mikulášek, CSc.
Head of Institute