에너지공학, 제26권 제1호(2017)
Journal of Energy Engineering, Vol. 26, No. 1, pp.76~83(2017)
https://doi.org/10.5855/ENERGY.2017.26.1.076

Overview of Coffee Waste and Utilization for Biomass Energy Production in Vietnam

Thenepalli Thriveni[1], Minsuk Kim[2], Ahn Ji Whan[2]†

[1]Hanil Cement, 302 Maepo-gil, Maepo-eup, Danyang-gun, Chungcheongbuk-do, 395-903, Korea.
[2]Carbon Mineralization Center, Korea Institute of Geosciences and Mineral Resources (KIGAM), 124, Gwahagno, Yuseong gu, Daejeon-305350, South Korea.

(Received 10 February 2017, Revised 27 February 2017, Accepted 2 March 2017)

Abstract

In this paper, the carbon resources recycling of the overview of coffee waste generation in Vietnam. Since few years, there has been a significant research studies was done in the areas of coffee waste generation areas and also waste water generation from coffee production. The coffee residue (solid) and waste water (liquid) both are caused the underground water contamination and also soil contamination. These residues contain high organic matter and acid content leads to the severe threat to environment. In second stage of coffee production process, the major solid residue was generated. Various solid residues such as spent coffee grounds, defective coffee beans and coffee husks) pose several environmental concerns and specific problems associated with each type of residue. Due to the unlimited usage of coffee, the waste generation is high. At the same time, some researchers have been investigated the spent coffee wastes are the valuable sources for various valuable compounds. Biodiesel or biomass productions from coffee waste residues are the best available utilization method for preventing the landfill problems of coffee waste residues.

Key words : coffee waste, environmental effects, utilization, biomass production, Vietnam.

1. Introduction

Over the past several decades, coffee production is a major export oriented industry in Vietnam. Coffee is one of the most significant agricultural export products in the world economy, next to other important oils and it is the most important and strategic commodity on which Vietnam's economy depends on. It has always been the most important cash crop and largest export product, which account 90 ~95% of exports [(1)]. Vietnam is the second largest country in the worlds coffee production and coffee exports bringing them high revenue in every year. As a lead coffee production country among the world, Vietnam faces a future serious environmental problems. Due to the environmental limitations, the country's coffee production can't continue the large production of coffee commodities. The main reason is climate change is expected significantly affect the coffee farming. The average temperatures increase in the dry season and it becomes longer and hotter and also water sources are very limited. In 2016, the government made a plan for the sustainable coffee production from 2020 and vision to 2030. This agenda aimed the sustainable management for economic and environmental resources for the coffee industry. The global production and consumption of coffee was showed[(2)] in the Fig.1, Fig. 2 and Fig.3.

The vast majority of coffee production is more than 3 tons for every 4 tons grown and it is exported, flowing from developing countries (like Brazil, Vietnam, and Columbia) principally to in-

†To whom corresponding should be addressed.
Tel : +82-43-868-3573 E-mail : ahnjw@kigam.re.kr

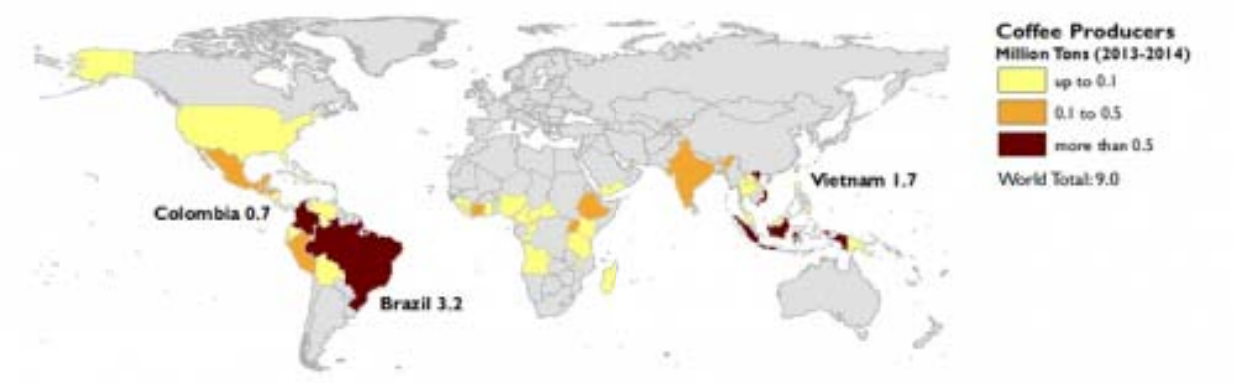

Fig. 1. Global coffee production in 2013-2014.

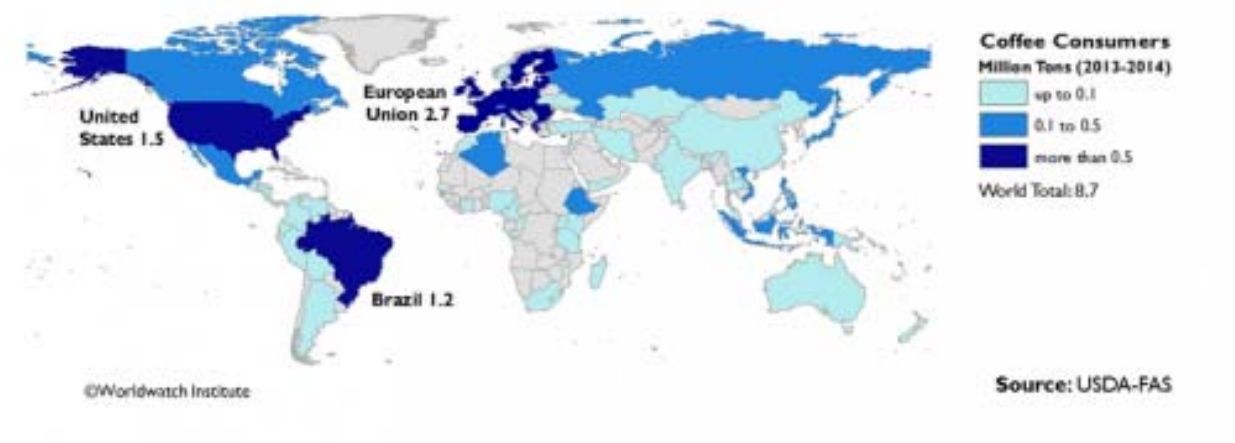

Fig. 2. Global coffee consumption in 2013-2014.

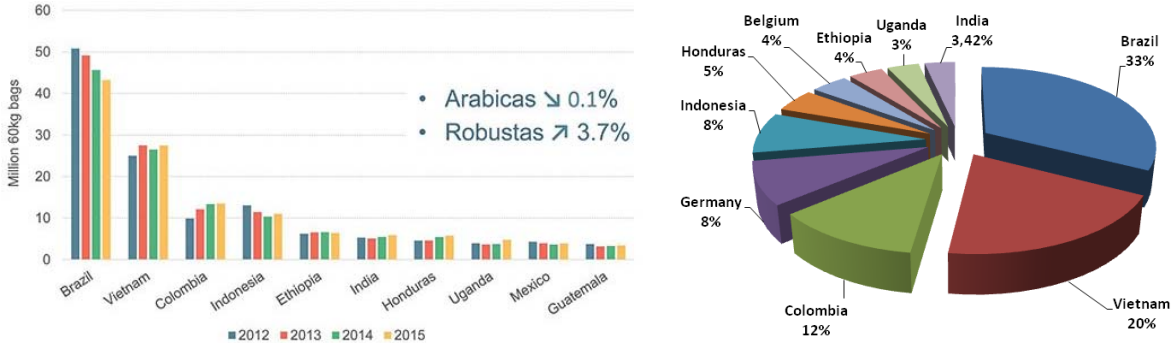

Fig. 3. Global Coffee Production from 2012-2015.

dustrial ones. Global coffee market rate was increased significantly during the years 2011-2015 and the future coffee production and market will be a tremendous growth during the years 2016-2020. The consumption of coffee in India, China, and Latin America is increasing led by the westernization trend, drive the market in the positive direction. Disposable income, rapid urbanization and population growth along with the emergence of cafe culture leads the global coffee market rate. Globally, there are three kinds of coffee products are available but there are certain limitations and challenges faced

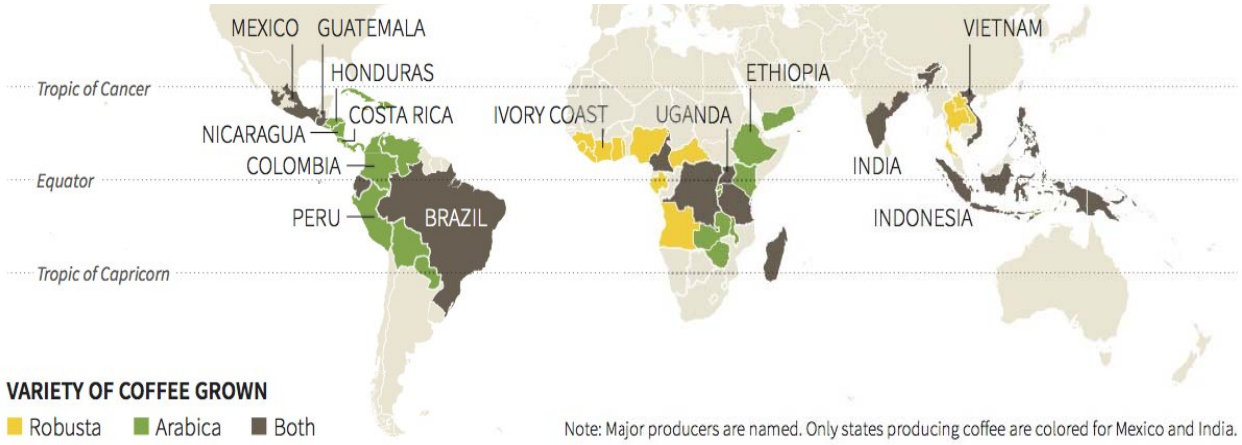

Fig. 4. Global Variety of Coffee Production

by the market mainly negative impact of climate change and production cost is increased [3] (Fig.4).

2. Envrinmental effects of coffee processing

GOV is developing policies and programs that encourage sustainable development of the agricultural production sector in general and the coffee sector in particular. GOV has selected the Public-Private Partnership (PPP) model as one of the key solutions for implementing sustainable agricultural development. Vietnam's coffee sector has been engaged in sustainable production also. Certified sustainable coffee production has been increasing among Vietnamese coffee producers, farmers, and traders [4].

500,000(7% Arabica, 93% Robusta) was produced and among those 15% of the dried cherry weight and the coffee residue was used as fertilizer and dumped. Coffee waste from either wet processing or dry processing is not fully utilized. At the same time coffee processing is an industry with a high energy demand. The use of coffee waste for biogas production (wet processing) or direct combustion should be further explored.

In general, the agricultural and the food sectors produce large quantities of waste, both solid and liquid forms. Due to the great demand and consumption of coffee, coffee industries released are large amount of residues, which are highly toxic and leads to the serious environmental problems[5].

In coffee producing countries, coffee waste constitutes are a major source of severe contamination. Currently in vietnam, coffee waste management systems are not well established. Several studies reported that untreated waste from traditional and modern industries is threatening surface waters worldwide, and it is severe in developing countries [6]. Water pollution is the gloomy setback for the development in coffee producing countries [7,8], and this also appears to be the case in Ethiopia and Vietnam[9-11]. It is estimated that more than two million tons of coffee waste is generated yearly[12]. In fact all coffee producing countries face this challenge, however generates a large amount of coffee processing wastewater (CPW), rich in suspended organic matter, organic and inorganic compounds in solution, with high polluting potential[13], the waste water from coffee industries has high concentration of organic pollutants[14-16] and is very harmful for surrounding water bodies, human health and aquatic life if discharged directly into the surface waters. This effluent is being directly discharged to the nearby water bodies and thus causing many severe health problems like spinning sensation, eye, ear and skin irritation, stomach pain, nausea and breathing problem among the residents of nearby areas[17,18].

3. Biomass production from Waste in Vietnam

In Vietnam, the energy development system [19] was showed in the Fig.5 (a) and (b). The primary energy sources are mainly from hydropower, coal, wind turbines and diesel etc.,

Since few decades, fast industrialization, urbanization and the economy's progress of Vietnam lead to growing high energy consumption. However, the energy sectors in Vietnam faces a challenges, and sources are limited. The energy sector of Vietnam foresees an imbalance in near future and dependence on fossil fuels.

3.1. Biomass sources in Vietnam

Currently, biomass is a major source of energy in Vietnam and one that the country is well endowed in. The recent surveys reported and estimated that nearly 90% of domestic energy consumption from rural areas is derived from biomass such as charcoal, agricultural residues (e.g. rice straw and husks) and wood. Particularly, in rural areas, biomass fuel is also an important energy source for small industries in Vietnam. We reported the potential utilization of biomass from the primary sources [20] such as energy crops, agricultural residues, other kind's residues, and forest as indicated in Fig. 6.

Biomass source was classified as four main groups with 19 types. 1. Agricultural residues:

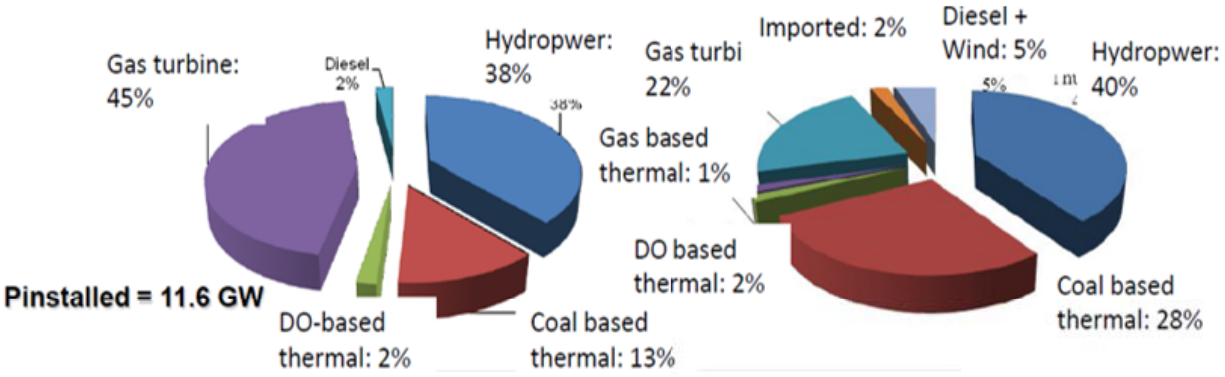

Fig. 5. Primary energy sources in Vietnam a) 2005 and b) 2014.

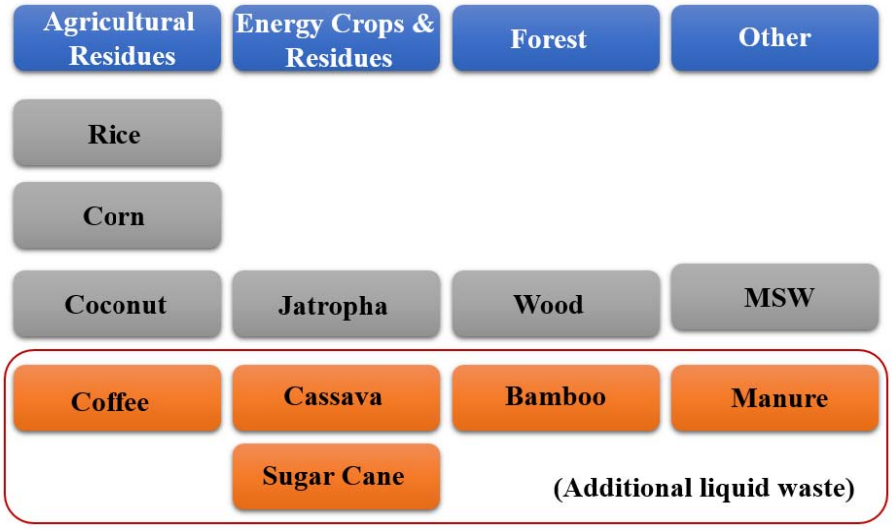

Fig. 6. Primary biomass energy sources (adopted from ref 7 and modified)

Cassava stem, peanut residues, coconut shells, husks, maize trash, sugar cane residues, coffee waste, rice husks etc., 2. Energy crops: elephant grass, energy trees and others., 3. Forest residues: bamboo, fuel wood and other charcoal etc., 4 others: construction wood, wood cheeps, sawdust, scattered trees, garden and home trees[21].

The detailed biomass energy sources (wood en-

Table 1. The primary biomass energy sources (wood energy and wood residues) in Vietnam (Adopted and modified from ref.22).

Biomass Resources	Amount for Energy usage (mill.tons)
Natural forest	14.07
Bare land	2.47
Planting forest	9.07
Fruit tree	0.41
Industrial perennial	2.00
Scattered tree	7.79
Wood cheeps	5.58
Sawdust and shavings	1.12
Building (timber from work and house repairs	0.80
Total	43.31

Table 2. The primary biomass energy sources (agricultural residues) in Vietnam (Adopted and modified from ref.22).

Biomass Resources	Amount for Energy usage (mill.tons)
Rice straw	40.00
Sugar wastes	7.80
Corn residues	9.20
Cassava stems	2.49
Rice husk	8.00
Bagasse	7.80
Groundnut shells	0.15
Coffee husk	0.17
Cashew nut shells	0.09
Others (estimated)	4.00
Total	74.90

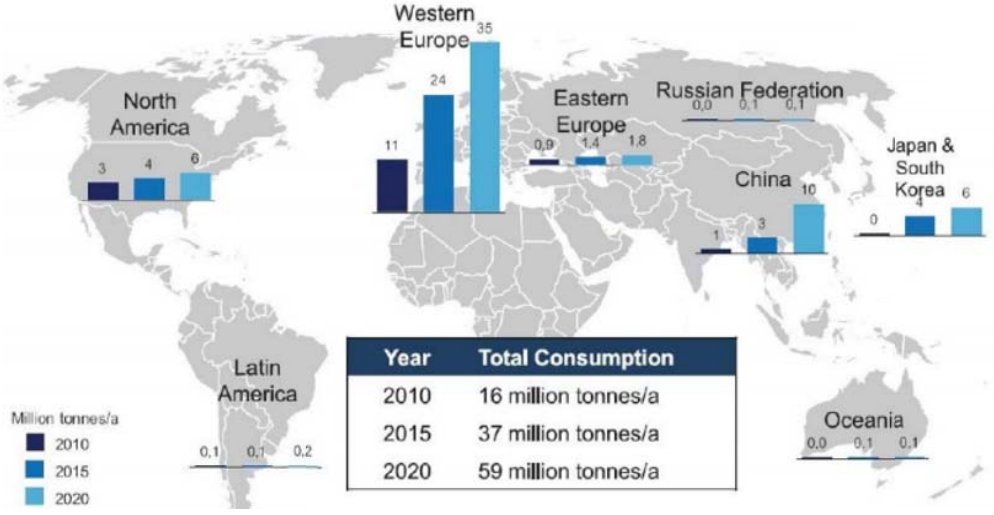

Fig. 7. Global biomass pellet consumption

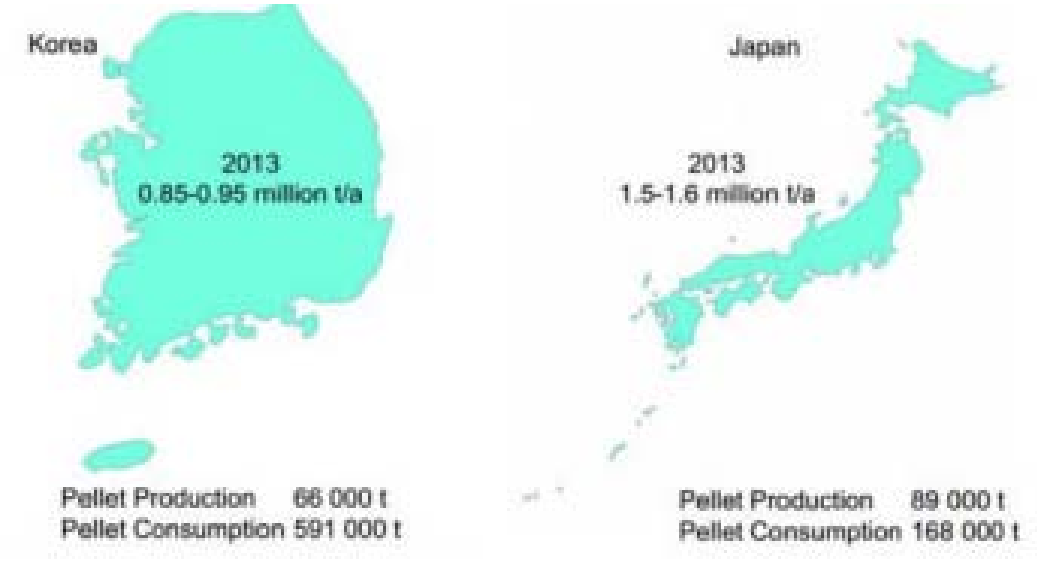

Fig. 8. Korea and Japan biomass pellet consumption

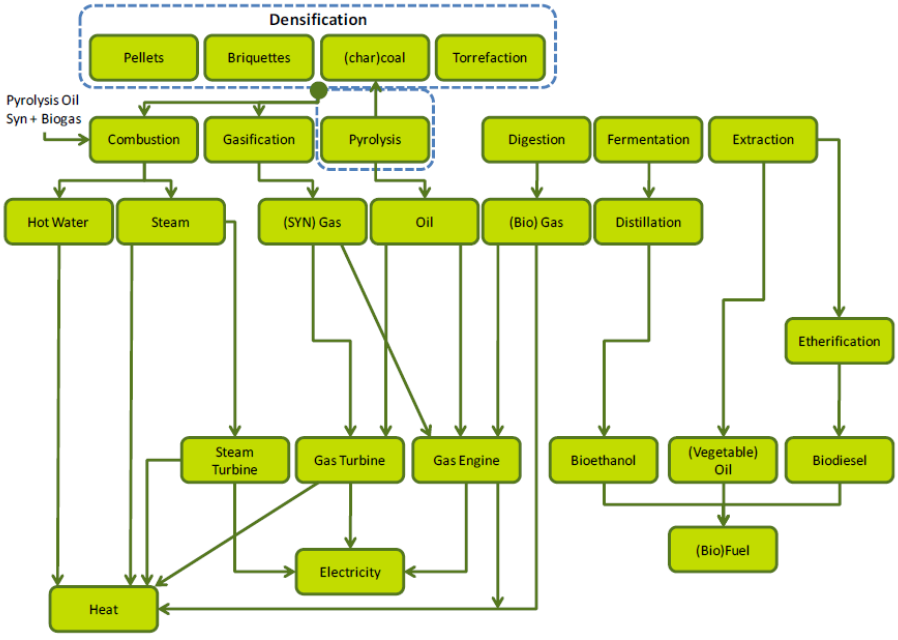

Fig. 9. Conversion Technologies for biomass production.

ergy and wood residues) given in the Table 1 and agricultural residues are given in Table 2.

There are several projects on biomass pellet utilization in Vietnam during the years 2000 -2016. Globally, biomass pellet consumption growth was randomly increased. The global biomass pellets market is forecasted to grow at CAGR of 11% over the period 2014-2019[22] (Fig.7 and Fig.8).

3.2. Conversion Technologies

The different biomass sources can be converted into several energy carriers (like oil, gas, pellets, or charcoal) or can be converted into energy by combustion. The different conversion technologies [22] and the possibility of conversion routes are presented in the Fig. 9.

\

4.Conclusions

Vietnam is being a developing country and considered as one of the significant potential of biomass energy (rice exporter, coffee exporter and also other food products such as cashew, coconut and wooden etc. Coffee waste can be as a good feed for biogas production. Coffee husk much higher gas potential than spent coffee husk. The use of coffee husk for mushroom production did not improve gas production and its rate. The pulp collected from wet processing gives much higher gas production coffee husk. Spent coffee husk has still significant gas potential. Coffee pulp can be used for low grade fertilizer. Pulp can be also be used as substrate for growing mushrooms. In Vietnam there are no sufficient large energy production projects in comparison to Thailand, Malaysia. Biomass pellet production and utilization is just in the beginning stage in Vietnam.

Acknowledgements

The authors are very grateful to the Korea Institute of Energy Technology Evaluation and Planning through the ETI program, Ministry of Trade, Industry and Energy (Project No. 2013T100100021) for financial support of this research.

References

1. Dan Bolton, Arabica in 2050, Stir web news, 2016, 1. (http://stir-tea-coffee.com /features/ Arabica-in-2050/).
2. Michael Renner, Coffee production near record levels, sustainable share rising, World watch institute web news, 2014, 1.
3. Christopher Woody, El Nino related weather conditions could endanger coffee crops around the world and drive up prices, Business insider web news, 2015, 1.
4. Nguyen Thi Huong, Tran Quoc Quan, Vietnam, 2012 Coffee Annual, GAIN Report VN2025, 2012.
5. Solange, I.M, Ercília, M.S.M., Silvia, M., José, A.T., 2011, Production, composition, and application of coffee and its industrial residues, *Food Bioprocess Technology*, Vol. 4, pp.661-672.
6. Beyene, A., Kassahun, Y., Addis, T., Assefa, F., Amsalu, A., Legesse, W., Kloos, H., Triest, L., 2011, The impacts of traditional coffee processing on river water quality in Ethiopia and the urgency of adopting sound environmental practices. *J Environ Monit Assess.*, Vol.184, pp. 7053-63.
7. Mwaura, P.K., Mburu, J.K., 1998, Effect of wet processing of coffee on river water quality. *Kenya Coffee*, Vol.63, pp. 2779-87.
8. Varunprasath, K., Daniel, N.A., 2010, Physico-chemical parameters of river Bhavani in three stations, Tamilnadu, India, *Iranica J Energy Environ*, Vol.1, pp. 321-25.
9. Haddis, A., Devi, R., 2008, Effect of effluent generated from coffee processing plant on the water bodies and human health in its vicinity, *J Hazard Mater.*, Vol.152, pp. 259-62.
10. Beyene, A., 2010, Development and validation of ecological water quality monitoring tools for river systems of Ethiopia, VUB Press, Brussels.
11. Jan C. von Enden, 2013, Treatment of wastewater Treatment of wastewater from Arabica coffee processing presentation, PPP Project PPP Project *Improvement of Coffee Quality and Sustainability of Coffee Production in Vietnam*, pp. 1-13.
12. Pandey, A., Soccol, C.R., Nigam, P., Brand, D., Mohan, R., Roussos, S., 2000, Biotechnological potential of coffee pulp and coffee husk for bioprocesses, *Biochem. Eng. J.*, Vol.6, pp.153-62.
13. Matos, A.T., Fia, R.F., Luiz, F.A.R., Características rastreáveis dos sistemas de tratamento de águas residuárias geradas no processamento de frutos do cafeeiro. In: L.Zambolim, (Org.). Rastreabilidade para a cadeia produtiva do café, *Visconde do Rio Branco: Suprema Gráfica e Editora*, pp. 321-77.
14. Chapman, C., 1996. Water quality assessments.

A guide to the use of biota, sediments and water in environmental monitoring, Chapman and Hill, London, United Kingdom.

15. De Matos, T.A., Lo Monaco, P.A., Pinto, A.B., Fia. R., Fukunaga, D.C., 2001, Pollutant potential of wastewater of the coffee fruits processing, *Federal University of Viçosa, Department of Agricultural Engineering*, Viçosa - MG, Brazil, http://www.ufv.br/ poscolheita/aguas/artigos/Pollutant.
16. INEP-Karnataka, Bioreactors for clean coffee effluents reducing water pollution in western ghat with appropriate technology solutions, http://www. inepkarnataka. org/pdfs/coffee.pdf and http:// www. inepkarnataka. 2001.
17. Deepa, G.B., Chanakya, H.N., de Alwis, A.A.P., Manjunath, G.R., Devi, V., 2002, Overcoming pollution of lakes and water bodies due to coffee pulping activities with appropriate technology solutions. In: Proceedings of the Symposium on Conservation, Restoration and Management of Aquatic Ecosystems, Centre for Ecological Sciences, Indian Institute of Science (IIS) and the Karnataka Environment Research Foundation [KERF].
18. Enden, J.C., Calvert, K.C., 2002, Limit environmental damage by basic knowledge of coffee waste waters, GTZ-PPP Project-improvement of coffee quality and sustainability of coffee production in Vietnam, http://en.wikipedia.org/wiki/Coffee wastewater.
19. Ministry of Industry and Trade General Directorate of Energy Presentation, Vietnam energy policy, IEEJ August, 2015.
20. Dagmar Zwebe, Biomass Business Opportunities Viet Nam, SNV Netherlands Development Organization Vietnam, March 2012, pp.1-85.
21. Nguyen Duc Cuong, (a) Identification of biomass market opportunities in Vietnam. Berlin: Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH, 2011 (b) Exploring Biogas Market Opportunities in Vietnam. Berlin: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2011).
22. Nguyen Dang Anh Thi, 2015, Production and utilization of biomass pellet in Vietnam, *International Renewable Energy Asia Conference 2015 ASEAN Renewable Energy Market Development under Energy Price Volatility*, pp. 1-14.