Plastic management to reduce environmental pollution

Gestión del manejo de plástico para reducir contaminación ambiental

Salvador Montesinos González
Technological University of the Mixteca
México, smontesinos@mixteco.utm.mx
https://orcid.org/0000-0001-6006-7790

Conrado Aguilar Cruz
Technological University of the Mixteca
México, conrado@mixteco.utm.mx
https://orcid.org/0000-0003-1585-292X

Moisés Manzano Herrera
Technological University of the Mixteca
México, moises@mixteco.utm.mx
https://orcid.org/0000-0003-0813-9771

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Abstract

There is an infinity of plastic products which have facilitated human life, but have also caused great environmental pollution, such is the use of polyethylene terephthalate (PET), which is a polymer in widespread use throughout the world. The vast majority of organizations, scientists, and others have understood this situation and have promulgated laws, designed strategies, environmental programs, etc., in order to contain or reduce their use or even recycle and reuse these materials, since once they are discarded they become polluting materials. Objective: Propose a program to reduce the pollution generated by some plastics in the municipality of Silacayoápam, Oaxaca, Mexico and in turn reactivate

the local economy in small local businesses through exchanges for basic basket products. Method: Using the documentary analysis technique, primary information was collected by conducting a direct survey of the inhabitants of the municipality, after which it was systematized in data record sheets, and the main challenges posed by the use of the polymer in the municipality were identified. Results: With the data collected, strategies for the use of plastic were analyzed and proposed, designing a management program for it at the local level that helps reduce the environmental impact, and also promote environmental culture in the municipality, and in turn reactivate the economy of local businesses. Discussion and conclusions: The generation of proposals and strategies for polluting waste management systems, allows education with a culture of collection and recycling and, in turn, supports small businesses affected by the pandemic and the inflation of basic basket products. This represents a huge challenge at the local, regional and national level through more efficient, inclusive and sustainable waste recycling, to reduce environmental and health problems.

Keywords: environmental impact, PET, management, collection.

Resumen

Existe una infinidad de productos plásticos que han facilitado la vida humana, pero también han causado una gran contaminación ambiental, tal es el caso del uso del tereftalato de polietileno (PET), que es un polímero de uso generalizado en todo el mundo. La gran mayoría de organizaciones, científicos y otros han entendido esta situación y han promulgado leyes, diseñado estrategias, programas ambientales, etc., con el fin de contener o reducir su uso o incluso reciclar y reutilizar estos materiales, y una vez desechados convertirse en materiales contaminantes. Objetivo: Proponer un programa para reducir la contaminación que generan algunos plásticos en el municipio de Silacayoápam, Oaxaca, México y a su vez reactivar la economía local en pequeños negocios locales a través de canjes por productos de la canasta básica. Método: Utilizando la técnica de análisis documental, se recolectó información primaria mediante la realización de una encuesta directa a los habitantes del municipio, luego de lo cual se sistematizó en fichas de registro de datos, y se identificaron los principales desafíos que presenta el uso del polímero en el municipio. Resultados: Con los datos recolectados se analizaron y propusieron estrategias para el uso del plástico, diseñando un programa de manejo del mismo a nivel local que ayude a disminuir el impacto ambiental, además de promover la cultura ambiental en el municipio, y a su vez reactivar la economía de negocios locales. Discusión y conclusiones: La generación de propuestas y estrategias de sistemas de manejo de residuos contaminantes, permite educar con una cultura de recolección y reciclaje y a su vez apoya a los pequeños empresarios afectados por la pandemia y la inflación de productos de la canasta básica. Esto representa un gran desafío a nivel local, regional y nacional a través de un reciclaje de residuos más eficiente, inclusivo y sostenible, para reducir los problemas ambientales y de salud.

Palabras clave: impacto ambiental, PET, gestión, recogida.

Introduction

The use of plastic-based products has increased considerably in recent years, and even more so during and after the pandemic, due, among other reasons, to low cost, availability, versatility, durability, water resistance, etc. (Schmaltz et al., 2020; Geyer et al., 2017). Plastic waste generated by humans has contributed to environmental pollution in the short and long term (Patricio et al, 2021), impacting on human health (Estrada et al., 2016; Zambrano et al., 2022; Schnurr et al., 2018).

The environmental problem has to be analyzed but not before studying the economic growth of the countries, and the conservation of the environment (Gómez et al., 2011). Pollution is one of the most serious problems worldwide and is a silent threat to life (Montaño and Sandoval, 2007), especially now after the pandemic with the use of more plastic products (Prieto, 2022). The causes that cause the contamination of a site in flora and fauna (Wu et al., 2019; Rist et al., 2018) are the inadequate disposal of Urban Solid Waste (MSW), Special Management Waste (SMR) and Hazardous Waste (RP) in vacant lots, warehouses, warehouses and patios of businesses, houses and industries (SEMARNAT, 2013).

The production and consumption of goods and services inevitably generate some type of waste, these can be solid, liquid and those that escape in the form of gases (SEMARNAT, 2016). The same source indicates that in Mexico, according to the most recent figure published in 2015, the generation of RSU reached 53.1 million tons, which represented an increase of 61.2% with respect to 2003. The State of Oaxaca in terms of solid waste They generated approximately 2,998 tons/day of this waste (SEMAEDESO, 2017), also considering that the existing infrastructure for the management of urban solid waste and special management in the state is insufficient, obsolete, and very precarious (Ruiz, 2020). The management of solid waste in the Mixteca must become a central point, although the number of tons registered in 2019 places the region in fourth place in waste production with 51 thousand tons, by 2020 it was already in second place at the state level with 86,410.1 tons (SEMAEDESO, 2017). In this context, this project will be carried out, whose main objective is to design a program to reduce pollution generated mainly by PET, which is the most used, and by other plastics|, this through basic activities such as changing, identifying and presenting a program according to the local conditions of the municipality and follow up on said program through continuous improvement (Montesinos, 2022). The results will be useful to reduce environmental pollution.

On the other hand, the general hypothesis is that the conditions exist to implement a program to reduce the contamination generated by PET. The proper

handling of this material will reduce greenhouse gas emissions and now raw materials.

Among the theories related to the use and handling of polymers, the following are considered important: Bronfenbrenner's ecological theory (1976); The Solid Waste Comprehensive Management Program (PGIRS), the first referenced theory mentions an environmental system based on the development of individuals through the different environments in which they move and that consequently influence their changes and development. While the program mentions aspects related to the generation, separation and treatment at the source of origin of waste, as well as its collection, transfer, transportation, treatment, recycling and final disposal of waste.

Another related theory is the theory of development that conceives development as a harmonious process, where the exploitation of resources, the direction of investments, the orientation of technological change and institutional transformations must correspond to the needs of present and future generations. Thus, development is presented as a process that requires global progress, both in economic and social matters as well as in the environmental and human spheres (Pichs, 2002).

Methods

The methodology used in this research is the descriptive method (Hernández, 2020; Rojas, 2007; Torres and Navarro, 2007), since it consisted of collecting information through direct questions, organizing, summarizing, presenting, analyzing and generalizing the results. results of the observations. This method involves the systematic collection and presentation of data to give a clear idea of a certain situation. The advantages of this study is that the methodology is simple, fast, short time and economical. Due to the nature of the research, it was convenient to distribute it into four activities, which were defined by the group of researchers, these were the following.

1. *Data collection*. This activity consisted of gathering all possible information from various sources in order to obtain a complete and accurate picture of the area of interest.
2. *Conducting surveys and interviews*. It was a laborious, meticulous and analytical stage, since the questions were defined and the surveys were carried out on the citizens of the municipality, basically it was 350 inhabitants of the municipality of Silacayoápam, the number of people was determined with a confidence level of 90% of a population of 2.156 people in total.
3. *Analysis of the information*. As part of the tasks that were carried out in this activity, it was to analyze the data collected, in order to formulate

strategies that would help to achieve the objectives and to design a good PET management program.

4. *Program proposal*. At this stage, the set of activities to be carried out was organized taking into account the application of human, material and financial resources in order to arrive at a proposal for a program for the collection and use of some plastics.

Results

1. *Data collection*. The information that was found on the main waste that is discarded in the municipality are plastics, aluminum, cardboard and iron. The respective percentages are presented below (Figure 1).

Main waste	Percentage
polymers	39
aluminum	19
iron	24
cardboard	6
others	12

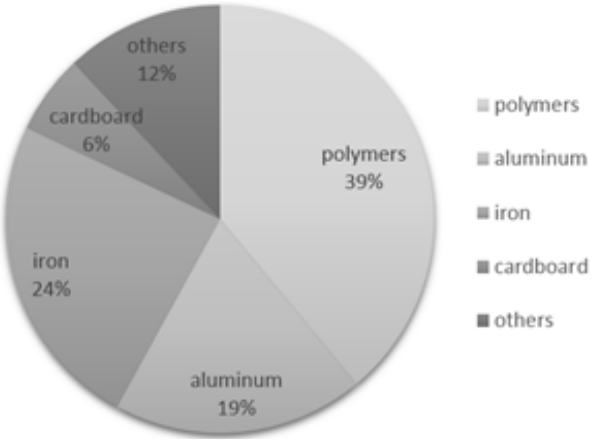


Figure 1. Main Waste of the Municipality of Silacayoápam. Source: Self made.

On the other hand, the volume of the different plastics that the municipality collected in 2022 with the implementation of the program that was implemented is shown in the following graph.

	Kilograms collected		
Month	**PET**	**LDPE**	**PVC**
January	251	71	178
February	224	67	162
March	290	69	160
April	278	72	165
May	269	65	174
June	271	81	188
July	230	79	191
August	247	80	178
September	305	74	166
October	270	61	187
November	289	77	194
December	336	92	221

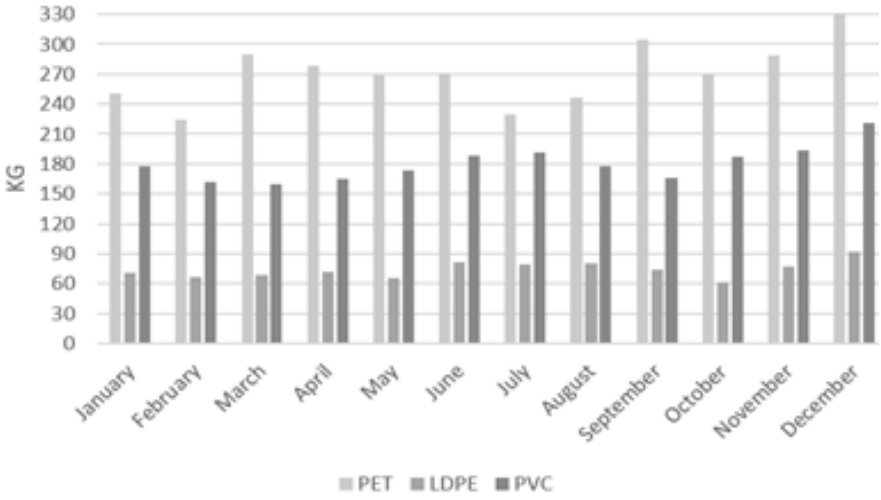


Figure 2. Volume of the different types of plastics recycled in the year 2022 (municipality of Silacayoápam). Source: Self made.

2. Conducting surveys and interviews.

The survey consisted of four questions that were carried out in a period of 5 weeks directly and in writing from house to house by social service students, these in turn are presented below (Table 1).

Table 1.
Survey format

Item	Questions	Answers				
1	How many plastic bottles do you throw away per day?	1	2	3	4	5 o mas
2	What do you do with the plastic you use?	Does no recycle			Recycle	
3	Consider it important to recycle plastic	very important	important	neutral	less important	without importance
4	Do you know of a collection center in the municipality?	Yes			No	I´m not interested

Source: Self made.

3. Analysis of the information

For the first question, the answer was that on average a person discards 1.98 bottles daily. Table 2 reflects an analysis considering the average according to the sample surveyed. It should be noted that this question is only related to the bottle product, and not to other large or small containers that are thrown away.

Table 2
Average bottles discarded

	Daily	Monthly	Yearly
Individual	1.98	59.54	724
Total average of the sample surveyed (350 people)	693	20,790	249,480

Source: Self made.

For the second question, the answer was that 24% of the population recycles, while 76% does not recycle discarded plastic.

But based on the comments that most people commented, it is that with this program that they started, they will surely store their plastic products to be recycled and exchanged.

It is worth mentioning that this pilot program will start, in an initial phase, in nine agencies and 10 neighborhoods that concentrate 91% of the municipality´s population, and once its application is analyzed, it will surely be applied to the rest of the municipalities.

For the third question, which is: ´Do you consider it important to recycle plastic´, the answers are found in Figure 3. In this, it is identified that the population indicates that it is very important to have a culture of recycling with 80.3%, that is, 281 people responded with this answer.

	Quantity	Percentage
very important	281	80.3%
important	53	15.1%
neutral	10	2.9%
less important	4	1.1%
without importance	2	0.6%
Totals	350	100%

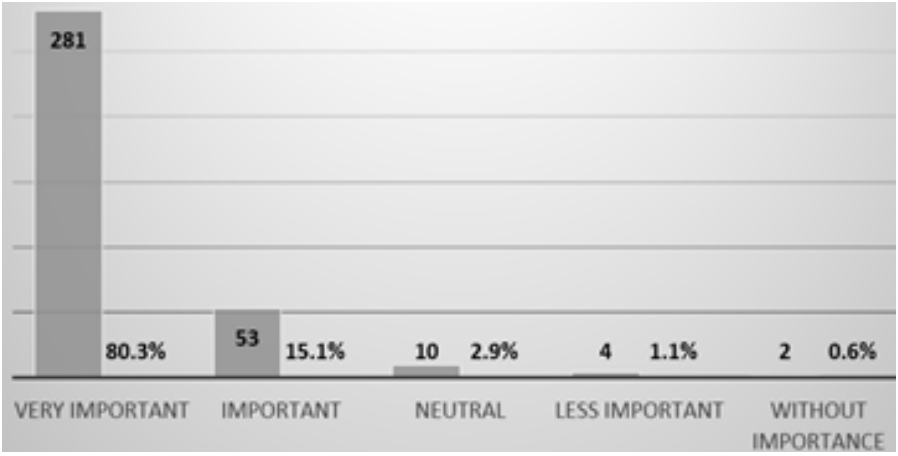
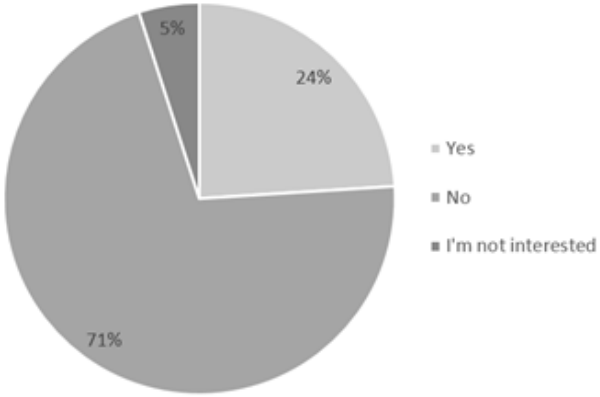


Figure 3. Percentage on the importance of recycling. Source: Self made.

Finally, the fourth question is related to the fact that, if you know of a collection center in the municipality, of this only 24% of the respondents know of a plastic collection center in the municipality, the other answers can be seen in the Graph 1.



Graph 1. Percentage of people who know of a collection center in the municipality. Source: Self made.

Based on the information available and collected, the following aspects were observed:

- There is no recycling program in the municipality.
- The volume of discarded plastics per person is high.
- There is interest among citizens in recycling plastic waste.
- 76% of people do not recycle.
- The conditions exist to implement a recycling program.

Based on the results of the analysis carried out, the collection, recycling and exchange program was generated, each of the activities carried out is described below.

4. Program proposal

A social program was planned, which goes by the name ECOPET with the objective of attending once a month (in a first stage) to the municipality of Silacayoápam, which consists in summary that the committee in charge of the program, makes a tour of the different agencies and neighborhoods of the municipality, to identify the inhabitants/families that correctly classify their recyclable waste, with the intention of observing, analyzing and exchanging for basic basket products.

As part of the functioning and operation of the program, it initially consisted of defining the activities to be carried out to bring the program to a successful conclusion, these in turn were directed by a coordinator and a committee designated and made up of citizens of the municipality.

1. Schedule the tour in the different agencies and neighborhoods with a Gantt chart (specifying exact dates and times).
2. Travel with the municipal van to the agencies and neighborhoods defined in the schedule.

3. Weigh the materials, these are weighed in the presence of the citizen to exchange them for basic basket products.

Table 3 shows the value in points of 1 KG of each of the plastic materials which, in turn, are equivalent in points to be exchangeable, and these are shown in Table 4.

Table 3
Value of materials

Weight	Material	Points
1 KG	LDPE (Low Density Polyethylene)	4
1 KG	PET (Polyethylene Terephthalate)	3
1 KG	PVC (Polyvinyl Chloride)	1

Source: Self made.

Table 4
Redeemable products

Product	Presentation	Points
Oil	1 lt.	20
Egg	1 kg.	18
Sugar	1 kg.	14
Bean	1 kg.	12
Rice	1 kg.	10
Oatmeal	1 kg	10
Juice	1 lt.	8
Juice	1 kg.	6
Cookies	1 package	4
Jelly	1 bag	2

Source: Self made.

Analysis and discussion

The amount of discarded plastics is increasing, and when policies and programs are not put into practice to collect them and allocate them to final disposal sites for proper handling, the result is, in the least severe case, pollution of the urban image. By implementing the program, the population and citizens will be made aware of the management, good use, recycling and recovery of plastics in the municipality. In addition, you will have more benefits such as:

- Support for small businesses for the purchase or exchange of points in their stores.
- Support for the family economy with products that complement the pantry.
- Adequate and timely use of recoverable and recyclable waste.
- Communities with good environmental habits.
- Reduction of unregulated dumpsites.

The experience gained allows us to propose more formal strategies that also involve recreational-creative educational activities that generate awareness and further motivate citizen participation in programs focused on mitigating environmental deterioration. The ultimate goal is for the population not only to understand concepts related to caring for the environment, but also to put them into practice during their daily activities.

In general, the results of the study suggest that educational campaigns on aspects of separation and classification of solid waste should be reinforced, considering some reasons put forward by some authors (Wu et al., 2019; Zambrano et al., 2022).

Conclusions

The community responded favorably to the high-density polyethylene collection, recycling, and exchange campaign/program, with large quantities being collected.

During the entire collection period, which was only five weeks, larger amounts of plastics other than PET were obtained, which was initially the objective of the program. However, it was also observed that the community does not have the culture of separating and classifying plastics, and that education campaigns for this purpose should be reinforced.

Waste management is one of the main problems faced by municipalities in Oaxaca and at the national level, given that waste generation is increasing exponentially, management requires generating continuous improvement proposals, strategies, and budgets that help care Ecology for the sustainable management of plastic waste.

On the other hand, support for small convenience stores was important given the situation of the pandemic that affected the economy and the sale of their products, this greatly helped families increase their economic income and, on the other hand, the citizens took advantage of and obtained a benefit from the

recycling and collection of plastic material that was to acquire products from the basic basket.

With this program, the environmental culture was improved through the collection, recycling and exchange of plastic waste, somehow reducing the ecological impact of this type of waste.

Declaration of conflict of interest

The authors declare that they have no conflict of interest. The information and data are those of the authors.

References

Estrada, A., Gallo, M. & Núñez, E. (2016). Contaminación ambiental, su influencia en el ser humano, en especial: el sistema reproductor femenino. Universidad y Sociedad [seriada en línea], 8(3), 80-86. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2218-36202016000300010&lng=es&nrm=iso

Geyer, R., Jambeck, J. R. & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Sci. Adv. 3, e10700782. https://www.science.org/doi/10.1126/sciadv.1700782

Gómez, C., Barrón, K. y Moreno, L. (2011). Crecimiento económico y medio ambiente en México. El Trimestre Económico. 78(311), 547-582. Recuperado de: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2448718X2011000300547&lng=es&tlng=es

Hernández, R., Fernández, C. y Baptista, P. (2020). Metodología de la investigación. 6 ed. D.F., México: McGraw-Hill.

Maldonado, L. (2006). Reducción y reciclaje de residuos sólidos urbanos en centros de educación superior. Revista Ingeniería, 10(1), 59-68. https://www.redalyc.org/pdf/467/46710106.pdf

Montaño, N. y Sandoval, A. (2007). Contaminación atmosférica y salud. Elementos: Ciencia y Cultura, 14(65), 29-33. https://www.redalyc.org/pdf/294/29406504.pdf

Montesinos, S. (2022, November 30). Continuous improvement to increase the productivity of companies [Master Conference]. In L. Navarrete-Zavala (Ed.), PROCEEDINGS Primer Congreso Internacional Multidisciplinario "Ciencia, Tecnología e Innovación: Una mirada multidisciplinaria a los desafíos globales de la Agenda 2030" (Online), (pp. 197-201). Manglar Editores. http://doi.

org/10.5281/zenodo.7482336

Patricio, A. L., Prata, J. C., Walker, T. R., Duarte, C., Ouyang, W., Barcelò, D., et al. (2021). Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations. Chem Eng J., 405, e126683. https://doi.org/10.1016/j.cej.2020.126683

Pichs, R. (2002). Los retos del desarrollo sostenible en América Latina. [En línea]. http://www.redem.buap.mx/ramon.htm

Prieto, R. G. (2023). Contaminación ambiental por plásticos durante la pandemia y sus efectos en la salud humana. Rev Colomb Cir, 38(1), 22-29. https://doi.org/10.30944/20117582.2203

Rist, S., Carney, B., Hartmann, N. B. & Karlsson, T. M. (2018). A critical perspective on early communications concerning human health aspects of microplastics. Sci Total Environ, 626, 720-726. https://doi.org/10.1016/j.scitotenv.2018.01.092

Rojas, R. (2012). Guía para realizar investigaciones sociales. México: Plaza Valdés.

Ruiz, M. A. (2020). Estado actual de la contaminación ambiental presente en la Mixteca Oaxaqueña. Journal of Negative and No Positive Results, 5(5), 535-553. https://doi.org/10.19230/jonnpr.3257

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (2016). Informe de la Situación del Medio Ambiente en México. Compendio de Estadísticas Ambientales. https://apps1.semarnat.gob.mx:8443/dgeia/informe15/tema/pdf/Informe15_completo.pdf

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) (2013). Informe de la Situación del Medio Ambiente en México. https://apps1.semarnat.gob.mx:8443/dgeia/informe_12eng/pdf/Informe_2012.pdf

Secretaría del Medio Ambiente, Energías y Desarrollo Sustentable (SEMAEDESO) (2017). Resumen Ejecutivo del Programa Estatal para la Prevención y Gestión Integral de los Residuos Sólidos Urbanos y de Manejo Especial en el Estado de Oaxaca (PEPGIRSUME). Recuperado de: http://www.medioambiente.oaxaca.gob.mx/transparencia/2017/pdf/normatividad/estatal/7.%20PROGRAMAS/Resumen%20ejecutivo%20PEPGIRSUME.pdf

Schmaltz, E., Melvin, E. C., Diana, Z., Gunady, E., Rittschof, D., Somarelli, J., et al. (2020). Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. Environ Int, 144,1-17. https://doi.org/10.1016/j.envint.2020.106067

Schnurr, R. E. J., Alboiu, V., Chaudhary, M., Corbett, R. A., Quanz, M. E., Sankar, K., et al. (2018). Reducing marine pollution from single-use plastics (SUPs): a review. Mar Pollut Bull, 137, 157-71. https://doi.org/10.1016/j.marpolbul.2018.10.001

Torres, Z. y Navarro, J. (2007). Conceptos y principios fundamentales de epistemología y de metodología. México: IIEE, Universidad Michoacana de San Nicolás de Hidalgo.

Wu, P., Huang, J., Zheng, Y., Yang, Y., Zhang, Y., He, F., et al. (2019). Environmental occurrences, fate, and impacts of microplastics. Ecotoxicol Environ, 184, e109612. https://doi.org/10.1016/j.ecoenv.2019.109612

Zambrano, C. C., Latorre, G. B. y Carrillo, B. J. (2022). Materiales poliméricos y el impacto ambiental: una revisión. Polo del Conocimiento, 7(6), 596-614. http://dx.doi.org/10.23857/pc.v7i6.4092