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Language Editing:

Lal Medawattegedara

Technical Assistance:

Priyantha Nawarathne

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Editorial

This is the Volume 13, Number 1 of the OUSL Journal 2018, the Journal of The Open University of Sri Lanka which is published biannually. The articles published in this Volume offer research-based knowledge and reflections from the fields of Social Sciences, Agriculture, Economics, Statistics, Nuclear Physics and Education.

The concept 'e-governance' or 'e-government' has captured the attention of many countries, including those in the developing world. The paper titled *The Role of E-governance in Curbing Public Sector Corruption (A Theoretical Overview*) explores the concept of e-governance and the possibility of its application to curb corruption in political and administrative systems. The authors problematize the notion of 'participation of citizens in government': they locate such citizen-driven initiatives as a phrase that lack vitality in the material sphere. The authors argue that there is a need to construct a platform for interactive participation of citizens in the state administrative processes. They suggest the introduction of "an interactive system which accepts people's feedback positively and considers them as serious matters". The concept of e-governance, according to the authors, has potential to build good governance through transparency in the administrative system.

Presently, there are health concerns surrounding the use of pesticide on agricultural produce as well as the presence of residue from such chemicals on such produce. The research study, *Quantification of Pesticide Residues in Selected Vegetables Using the QuEChERS Method* addresses this timely issue by focusing on the modes by which the QuEChERS method could be optimized for analysis of multi-residue pesticides. The researchers have tested locally grown vegetables from specific geographic locations for the presence of Diazinon, Chlopyrifos, Fipronil, Prothiofos and Tebuconazole residues using reliable technology. The findings do not offer a dismal picture with regard to fresh fruits and vegetables on the market, yet the researchers insist on the idea of introducing a tracer system to obtain critical details relevant to the application of pesticides for

further studies in order on minimizing the pesticide residues on fresh fruits and vegetables.

Colombo has been able to emerge as a location of significance in South Asia during the past few years. However, problems such as those related to essential needs, in particular water, and have prevented the city of Colombo reaching its maximum potential. While many ad-hoc measures have been undertaken by different parties, the problem remains unsolved due to the lack of sustainability of the solutions. The authors of the article *Price Elasticity of Demand for Pipe-Borne Water: A Pre-Requisite for Solving the Water Problem in the Colombo City* have investigated a sustainable solution to resolve the concerns of water supply in the city. The research has focused on how a part of the problem intensified by the lack of financial sustainability of the main organization instrumental in the provision of water to the Colombo city could be resolved via a tariff revision, and thereby enabling the authorities to ensure continuous and complete supply and distribution of water throughout the city. In conducting the study, the authors have clearly identified, with reference to previous literature, the research gap to be addressed as well as the practical problem and the methodology to be adopted to conduct the study. They have also conducted the data collection and analysis for an adequate sample, utilizing widely-used statistical techniques, and have interpreted the results, in an objective manner. The findings of the study support the claim that a tariff revision targeted at discouraging wasteful consumption of water while ensuring social efficiency and welfare is an important measure towards resolving the water problem in the Colombo city. As the authors have conducted the study adopting scientific methods, the results of the study and the interpretation of the results can be deemed reliable. Furthermore, the expected implications of the study could be realized if the results are incorporated into decision making.

In Sri Lanka, the tourism sector continues to perform significantly well and is considered one of the main sources of foreign exchange earners to the national economy. Despite Sri Lanka's natural beauty and unique cultural traditions—the primary attractions for tourists—the country suffered from setbacks caused by the 2004 Tsunami disaster and the 2009 world economic crisis. Yet, the post-civil-war

period saw tourist arrivals in the island growing steadily. Forecasting is an essential analytical tool in tourism policy and planning. The paper titled *Tourist Arrivals in Sri Lanka: A Comparative Study of Holt-Winter's versus Box-Jenkin's Modeling Methods* compares Holt-Winter's and Box- Jenkin's methods of modeling the tourist arrivals and recommends a better method to forecast the tourist arrivals in Sri Lanka. Based on the forecasting accuracy measures employed by the researchers to test both models, the Box-Jenkin's method outperformed Holt-Winter's method. Thus, the researchers argue that since accuracy of forecasts plays a vital role in the planning of tourism, the authorities should pay attention to the model that offers the best accuracy.

Cement can cause external and internal radiation exposure due to the presence of natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K in the raw materials used to manufacture it. Abeydeera *et al*, in their paper *Estimation of Radioactivity and Associated Radiological Hazards of Cement used in Sri Lanka* discuss the specific activities of radionuclides in fly ash that is used to make some varieties of cement. Fly ash is produced by combustion of coal in coal power plants. The highest specific activities of ^{226}Ra and ^{232}Th were observed in some brands of cement where higher amounts of fly ash were added. The radiation exposure risk due to the presence of radionuclides in cement was estimated by finding some indices such as the Indoor Absorbed Dose Rate and the Annual Effective Dose. The specific activities of radionuclides in cement were used to calculate these indices. These specific activities were measured by high resolution gamma spectrometry. If the annual effective dose is within the internationally accepted value, the use of cement could be considered safe. The calculated Annual Effective Dose Values for all studied cement samples used in Sri Lanka were lower than the recommended maximum permissible public dose of 1.0 mSv y^{--1}. Therefore, the studied cement samples did not show any significant radiation hazard and was considered safe for construction work.

The Batcher of Education in Drama and Theatre Programme offered by the Faculty of Education, The Open University of Sri Lanka has undergone a complete review after seven (07) years of its implementation, In the study, *Analysis of the Problems of and the*

Suitable Solutions for an Initial Teacher Training Programme Conducted through the Distance Mode, the researchers examine the perceptions of the newly reviewed program among teachers and students. Data were collected from all stakeholders using multiple methods. Through triangulation of data, it could be revealed that teachers and students have similar perceptions about the curriculum, lesson material and instructional processes used in the programme. However, teachers were critical about the actors' role played by student teachers in classrooms and the limited skills exhibited during practical teaching. Lack of focus on drama and theater, duration of teaching practice, limited support provided by the schools and mentors during teaching practice and the lack of opportunities for human interaction were identified as reasons leading to the perceived problems among teachers/students. Among the recommendations suggested by the researchers are, changing the focus of the curriculum, application of innovative methods in contact sessions and promotion of close interaction between teachers and students.

Professor Shyama R. Weerakoon
Editor in Chief/OUSL Journal
Email: ouslj@ou.ac.lk
https://orcid.org/0000-0003-0975-2738

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The Role of E-governance in Curbing Public-Sector Corruption (A Theoretical Overview)

Dodan Godage Kanchana[1]*, Athulasiri Kumara Samarakoon[2]

[1,2]Department of Social Studies, The Open University of Sri Lanka, Nawala, Sri Lanka

Abstract

A corruption free society is a prerequisite for development and good governance. Corruption is seen as an impediment to the development process of developing countries. Nevertheless, there are numerous efforts taken to prevent corruption in the public sector of those countries. One of the main strategies used to curb institutionalized corruption in the public sector today is use of e-governance, a by-product of ICT, which is an efficient and effective strategy. According to Robert Klitgaard's (1988) definition Corruption = Monopoly + Discretion – Accountability. The increase in the monopoly and the discretionary power of the public-sector officials in decision making and implementation lead to a decrease in accountability of public sector officials while increasing corrupt practices.

This study is aimed at identifying how e-governance could play a role to diminish the monopoly and the discretion power of the public-sector officials and thereby curb institutionalized corruption in the public sector. When considering the effectiveness of the e-governance

**Corresponding should be addressed to Ms. D. G. Kanchana, Department of Social Studies, The Open University of Sri Lanka.*
Email: *dgkanchana84@gmail.com*
https://orcid.org/0000-0002-3493-9732

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as a strategy, some of the examples were drawn from the Sri Lankan context.

The study is based on secondary data. Books, articles, statistical records, relevant reports and websites were used as the sources of data. Largely a descriptive analysis method was used in the analysis of data. The study reveals that the use of ICT enhances transparency and accountability of public sector activities; and by being more accountable in the performance of their duties goods and services are efficiently being provided to the public.

Key words: Corruption, Public Sector Institutions, E-governance, Sri Lanka.

Introduction

Corruption is recognized as a major impediment for development and good governance mostly in the developing world though it is never confined to that region only. However, extreme poverty, violence and political discrimination in the developing world are further aggravated due to the existence of extreme corruption in those countries. As Iqbal and Seo (2008, 51) point out corruption is “sky high”, “very serious”, “an epidemic”, “highly common”, “a social ill”, “a major crisis”, “at an alarming stage”, and “extreme” in the Third World.

Even though e-governance is not the first and last method to curb corruption in the public sector, it is being practiced very efficiently in the developed countries and in a few developing countries as well. In general, developing countries have succeeded much in implementing e-governance. Their efforts to apply the tools and strategies of e-governance have been visible since the last couple of decades.

According to the United Nations E-government Survey 2014, 20 Asian countries practice e-governance well to achieve good governance while reducing corrupt practices. These countries are: The Republic of Korea, Singapore, Japan, Israel, Bahrain, Malaysia, Sri Lanka (United Nations Department of Economic and Social Affairs, 2014, 28). There are examples of other developing countries that have taken some sort of initiatives to establish e-governance to reduce corruption even though they have lagged in the implementation of e-governance.

International organizations such as the World Bank (WB), Transparency International (TI), and the United Nations Development Programme (UNDP) provide evidence of the misuse of public money and property and its adverse impact on governance. Furthermore, those organizations often try to encourage developing countries to move from traditional method of governance to the use of modern technology such as the application of ICT skills for the improvement of good governance practices.

Lee's (2017) research on *The Impact of E-government on Corruption Control* in 172 countries and found that the level of E-government development positively affects corruption control in each of those countries. Also, the impact of corruption control through E-government is strong in non-OECD (The Organization for Economic Co-operation and Development) countries but it is not so in OECD countries (Lee 2017:28) because they have already developed socially and economically and are equipped with all the bases for a transparent government and corruption management through E-government. When it comes to the non-OECD countries, since they are currently developing in all fields, E-government development can contribute more effectively to creating a transparent government (Lee: 2017:28).

So, it is clear that e-governance has its own potential to ensure transparency and accountability by reducing administrative mal practices such as public-sector monopoly and the discretion.

Statement of the Problem

According to donors' perspective, corruption is the greatest obstacle to economic development and it is discounting the rule of law. The institutional framework and capacity are essential requirements for economic development. A huge amount of public money and public property are being wasted due to corruption in public sector institutions. Such corruption directly and indirectly contributes to the deprivation of the poor. Corruption in any sense undermines the institutions, ethical values and justice. The Global Forum II which was held in Hague in 2001 on Fighting Corruption and Safeguarding Integrity (Iqbal and Seo, 2008, 52) described corruption as "a virus capable of crippling government, discrediting public institutions and

private co-operation and having a devastating impact on the human rights of populations" (Ibid). If citizens have access to information in a transparent manner, it enhances the responsibility and accountability of the governing process by reducing the monopoly of power and the exercise of discretion. Robert Klitgaard (1988) defined corruption by providing an equation, i.e., Corruption = Monopoly + Discretion - Accountability. The possibility of corruption is proportional to the monopoly of power and the exercise of discretion (Lee: 2017). In other words, if the institutional background is strengthened to prevent the increase of institutional monopoly and discretion, then the institutional accountability will increase. Most of the studies have already revealed that e-governance has that potentiality. Consequently, this study was directed by the research problem of how e-governance can play a role in diminishing the monopoly of power and the exercise of discretion thereby curbing the corruption in public-sector institutions.

Objective

The main objective of this paper was to identify how e-governance can play a role to reduce the monopoly and the discretion power of the public-sector officials thereby curbing the institutionalized corruption in the public sector with special reference to the Sri Lankan context.

Methodology

This study was qualitative in nature and it used sources such as books, articles, statistical records, relevant reports and websites as the secondary data collecting means. In this paper, since the motive was to undertake a theoretical analysis on the concept of e-governance and to find out how its strength would support in transforming a public sector working environment to more accountable, transparent and reliable place and thereby reducing the monopoly of power and the discretion, this was not an in-depth analysis on the Sri Lankan context. However, some of the examples were drawn to explain the varieties of capabilities of e-governance in curbing public-sector corruption and to explain the issues in the implementation of e-governance in Sri Lanka. The nature of the presentation of findings is mostly become descriptive.

Theoretical Framework

Governance, E-governance and E-government

There is no standard definition for the term e-governance. Different organizations and institutions use their own way to define the same. Occasionally, the term 'e-government' is also used instead of 'e-governance'. 'Governance' and 'government' are not synonyms. The term 'governance' may be described as a process by which a society steers itself. In this process, the State, Private Enterprise and Civil Society interact with each other, articulate their interests, exercise their rights and obligations and mediate their differences (Saxena, 2005, 313). In other words, citizens and organizations are sharing their goals, interests by creating, and executing decisions and actions. Those citizens and organizations may or may not have formal authority and policing power (Iqbal and Seo, 2008, 54). 'Government' refers to an institution which exercises the authority derived from a society in a legal and formal manner. Similarly, there is a difference between e-governance and e-government. "E-governance (Electronic Governance) or Digital governance is the effective use of information technology to improve the system of governance that is in place, and thus provide better services to the citizens" (Saxena, 2005, 313). As such e-government can be taken as the first step of e-governance. It can also be defined as "the use of emerging ICTs such as the Internet, World Wide Web (WWW) and mobile phones to deliver information and services to citizens and business (Iqbal and Seo, 2008, 55).

The World Bank definition on e-governance can be mentioned as follows.

> *"E-Government refers to the use of information technologies (such as Wide Area Networks, the Internet, and mobile computing) by government agencies that have the ability to transform relations with citizens, businesses, and other arms of government. These technologies can serve a variety of different ends: better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management. The resulting benefits can be less corruption, increased transparency, greater convenience, revenue growth, and/or cost*

reductions." (World Bank Website; Accessed on: 26/10/2014].

The United Nations defined e-government as "utilizing the Internet and the world-wide-web for delivering government information and services to citizens" (Palvia and Sharma, n.d: 01). A government can also govern the country through electronic tools. Besides, it has more authoritative power to encourage the use of ICT in a broader sense of governance. The strategic objective of e-governance is to support and simplify governance for all parties—government, citizens and businesses (Backus, 2001, 03). It further provides citizens access to information and make them aware of the political process, services and choices available. Finally, a transition from passive information access to active citizen participation can be seen by informing, representing, encouraging, consulting and involving the citizens (Backus, 2001, 03).

Initiatives of E-government

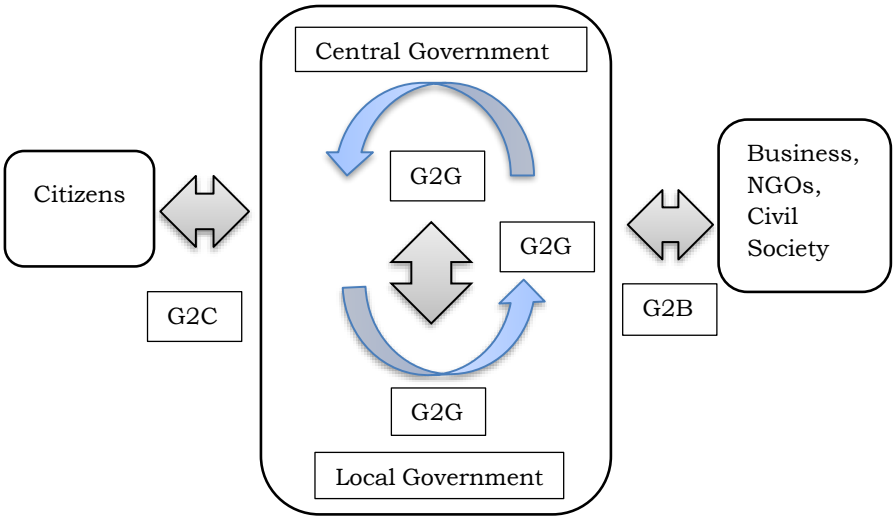
The initiatives of the E-government can be categorized as follows.

01	Government to Government (G2G, internal),	Interaction among government officials within an office or offices. Eg. Using e-mail for internal government communication.
02	Government to Employees (G2E, internal)	Giving services to employees. Eg. Pension Management System.
03	Government to Business (G2B, external)	Government services for the business societies. Eg. Government Procurement Process through the Internet.
04	Government to Citizens (G2C, external)	Creating interaction among government and citizens. Eg. Government services through the Internet such as online publication of government examination results, job announcements and application-downloading facilities.

(Source: Iqbal and Seo, 2008: 53).

Figure 1: E-government Initiatives

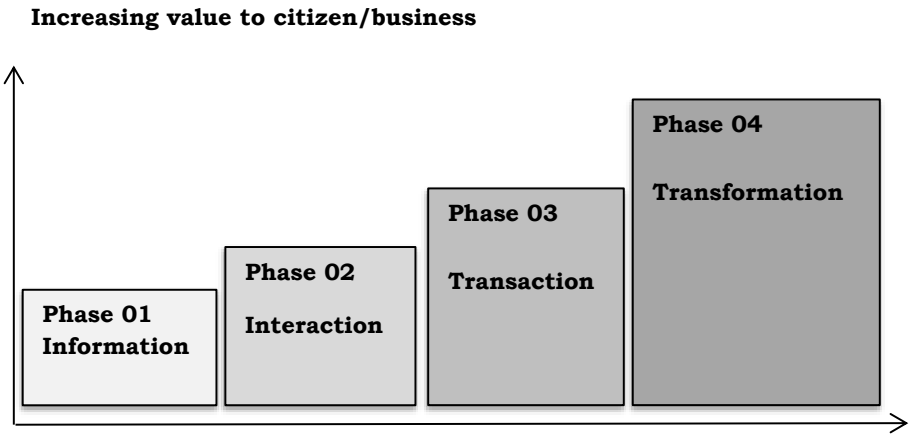
Similarly, the above-mentioned interactions of the main groups of e-governance can be figured out as follows.



(Source: Backus, 2001:04).

Figure 2: Interactions between main groups in e-governance

E-governance is not merely a government website available on the Internet. It is more than that. It must determine all the political, social, economic, technological etc. factors. A government can start the process of e-governance simply but later it must follow other phases to be supportive of the complex demands of people. The process of e-governance consists of four phases as shown in the E-governance Maturity Model (Figure 03) developed by Gartner (An International E-business Research Consultancy Firm) (Backus, 2001: 05). This model includes four phases such as Information, Interaction, Transaction and Transformation (Backus, 2001: 05). The government may not be able to establish all the phases at the same time but after starting the first phase, the other phases will be gradually developed in response to the demands of people. Its gradual increase will correspondingly enhance the value towards the citizens/business/employees/government. The complexity of the process of e-governance is illustrated in Figure 03.



(Source: Backus, 2001:05).

Figure 3: Gartner's E-governance Maturity Model

In Phase 01, the display of information through a website in the Internet can be seen. For example, if it is a G2C, the information may be related to the institutional vision, mission, structure, addresses, opening hours, responsible employee details, rules and regulations etc. In Phase 02, G2C interaction will be going on with the activities of downloading forms on websites, filling applications with the help of online facilities and submitting (permits, death/birth certificates), e-mails etc. The third phase is more complex and the use of paperless transactions with legal certification and the use of digital signatures can be seen. For example, license application renewals, vehicle registration, payments of taxes, tickets and fines could be achieved by maintaining personal accounts such as *myfines*, *mytax, mylicenses*. In the fourth phase, there may be personalized websites with integrated personal accounts for all services (Backus, 2001: 05). The change of traditional government culture into e-culture is visible at this stage. Throughout these four phases, the most important factor is mutual understanding of each party and the increase in dealings through the help of technology.

Defining Corruption

There is no commonly accepted single definition of corruption. Many researchers and research organizations have presented different interpretations on corruption based on their research activities. According to Saidman (1978, 48) it includes bribery, extortion,

speculation and nepotism of public officials. Government corruption can be considered as the sale by government officials of government property for personal gain (Shleifer and Vishny, 1993:599). For example, government officials collect speed money for providing services such as issuing permits, license etc. Transparency International in its 2014 report on *Curbing Corruption in Public Procurement: A Practical Guide* has defined corruption as:

> *"the abuse of entrusted power for private gain". "Private gain" must be interpreted widely to include gains accruing to the government official, his or her family members, close friends, political party, favorite charity, hometown or a corporate or other entity in which the official or the official's family or close friends have a financial or social interest" (Transparency International, 2014: 06).*

According to Robert Klitgaard (1988), "A corrupt official deviates from the formal duties of a public role because of private-regarding (personal, close family, private clique) pecuniary or status gains; or violates rules against the exercise of certain private-regarding behavior" (Azfar, Lee and Swamy, 2001: 44). Klitgaard has made an equation to define corruption as follows:

"Corruption = Monopoly + Discretion – Accountability"

All the public officials have the power specified by the government directly or indirectly to take decisions on worthy services and put them into action and it is called the monopoly of the public-sector officials.

Discretion refers to the freedom to judge or act. Public officials have the freedom of taking decisions according to their own opinions on various matters related to the supply of public goods and services. Accountability refers to being responsible for the execution of duties. For the above equation, when there is a combination of both monopoly and discretion, it results in the decrease in the

accountability of public officials and it tends to increase corrupt practices. Those corrupt practices can be named as misappropriation of public money and equipment, offering favors to people who propose gratification, acceptance of gifts, abuse of official position or power, under assessment of taxes, allotment of lands at cheap rates etc. (Goel, 2007: 200). Eventually, any kind of illegal action to gain a legal service, facility or right can be considered as a corruption. Furthermore, citizens, businessmen, bureaucrats and political representatives are the main stakeholders of the corruption process.

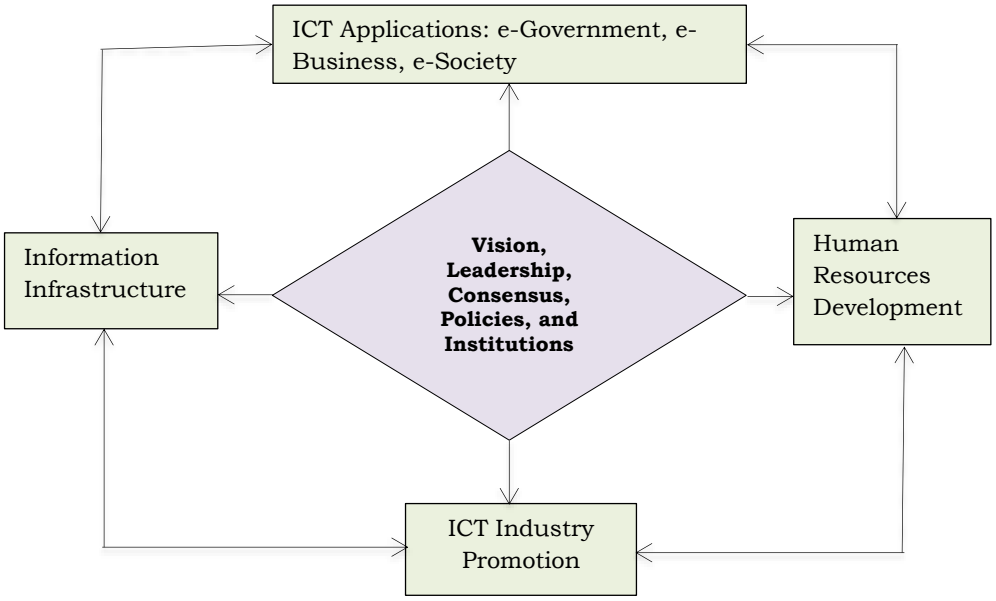
E-governance: Sri Lankan Experiences

Sri Lanka's e-governance policy originated with the vision of "adopting ICT in all its aspects to make government more efficient and effective, improve access to government services, and create a more citizen centric government" (Information and Communication Technology Agency of Sri Lanka (ICTA), 2009: 01). The government of Sri Lanka officially launched the e-Sri Lanka programme as the first National E-development Programme in 2002 (ICTA, 2009). The main aims were to improve public services, quality of life of the people, poverty eradication and socio-economic development (ICTA, 2009 and Karunasena, 2010). Under the ICT National Policy, all the government organizations can create their own policies and procedures but there should be a unified approach for providing e-government services to achieve the following objectives:

I. *Improved efficiency and effectiveness of government organizations in Sri Lanka thereby making each government organization's budget go further,*
II. *Ease and accessibility of government information and services for citizens, and other government organizations,*
III. *Promote good governance,*
IV. *Develop ICT competence among government employees,*
V. *Manage ICT resources in sustainable manner (ICTA, 2009: 02).*

Also, the ICTA as the primary Agency for making ICT policies and actions has thoroughly emphasized the scope of ICT application as "all government organizations; Ministries, government Departments,

Provincial Councils, District Secretariats, and Divisional Secretariats and Local Authorities, Government Corporations, Statutory Bodies, and Companies fully owned by government" (ICTA, 2009:03). Its e-government initiatives have been established as an integrated approach. It means that ICT application through one sector alone does not benefit in achieving the desired targets. It must include varieties of stakeholders as the beneficiaries as well as the key supporters to enable the country's long-term development while ensuring broad ownership and long-term sustainability (Rainford, n.d.). Thus, Sri Lankan government's broader aspects of e-governance can be shown in Figure 04. The government has initiated e-governance by ensuring both capacities of human resources and infrastructure at the same time. It means, without improving the human literacy level on ICT, the implementation of ICT comes to nothing. The continuation of ICT infrastructure development is also essential for the continuation of e-services.



(Source: Rainford, n.d: 05).

Figure 4: Design of e-Sri Lanka

Thus, some of the government organizations and their e-services can be tabulated as follows:

Table 1: Government Organizations and their e-services

Government Organization	E-services	
Mahaweli Authority of Sri Lanka	1	Inquiry (SMS based) on reservoirs' storage details
Department of Examinations	2	Issuance of certificates and copies.
	3	Application for re-correction.
National Water Supply and Drainage Board	4	Billing and payment history and bill payments.
Sri Lanka Bureau of Foreign Employment	5	Examination results.
	6	Employment opportunities.
	7	Payment service.
Sri Lanka Railways	8	Purchase of Tender Documents.
Sri Lanka Tea Boards	9	Reasonable Price Inquiry.
	10	Elevation average price inquiry.
Merchant Shipping Division	11	Issuance/renewal of Shipping Agent License.
	12	Issuance/renewal of Container Operator License.
	13	Issuance/renewal of Freight Forwarders' and Non-vessel Operating Common Carrier (NVOCC) License.
	14	Vessel-wise License Issuance.
	15	Addition of Principals' License Issuance.
Department of Labor (Employee Provident Fund Activities)	16	View and change EPF profile.
	17	View EPF account details.
	18	View refund status.
	19	View housing loan details.

Department of Government Factory	20	Purchase of Tender Documents.
Department of Motor Traffic	22	Online Purchase of Vehicle Information.
	23	View ongoing vehicle registration number by vehicle category.

(Source: ICTA, 2012: 26-27).

Results and discussion

The strength of E-governance in diminishing the monopoly of power and the exercise of discretion

Theoretically it is very clear that the usage of ICT will decline the misuse of monopoly of power and exercise of discretion by public sector officials. Now the discussion will move towards examining how that could happen using the data related to the Sri Lankan context.

As shown in the Figures 01 and 02, e-government initiatives promote an interaction between the different types of stakeholders such as the political representatives, administrators, citizens, technical supporters, private sector institutions, businessmen etc. Because of the engagement of many stakeholders in decision making and implementation, there is no space for the government monopoly resulting in its gradual reduction. The e-government policy of the Sri Lanka has been positively supported to its capacity building process as a prerequisite to the development since it has initiated e-governance following both top-down and bottom-up approaches. The top-down approach is used to change the traditional administrative culture into e-culture by changing the traditional administrative mindsets. The bottom-up approach encourages the participation of other stakeholders while enabling them through the terms of ICT skills and providing varieties of services, facilities, etc. Because of this G2C and G2B interactions, in other words, when the government activities are open to the citizens and businesses, the use of discretion of officials is decreased.

E-governance benefits in measuring the performances of public officials with facts and information. Therefore, it reduces the space for the misuse of power for illegal activities. E-governance helps to create the office environment to initiate Performance Management Processes (PMP). PMP is not a single task and it consists of a number of efforts to make the office environment like 'pay for work'. When there is a system to measure and evaluate the performances of workers, individually as well as collectively, as a group or an institution, it motivates people and makes them more competitive. It helps to develop moral sense and shame on illegal activities. It makes the workers more accountable and responsible for their performances. Before the establishment of e-government policies in Sri Lanka, the administrative culture was very rigid to change. Due to different types of technological improvements, people-friendly public offices and effective services with more confidence and trust can be seen.

E-governance is a prerequisite to implement Citizens' Charter in the public sector. It can easily inform citizens through electronic media and it helps to create a strong relationship between public sector workers and common people. Before the implementation of Citizens' Charter, the right for information and its transparency are required. When a government attempts to follow and establish the basic e-governance initiatives, it is automatically creating the necessity of free channels to access information. These types of actions strategically lead to a corruption free society. When the common people and other stakeholders know how the public-sector institutions function according to the rules and administrative procedures, they will also follow the proper channels for the services and that will also help to reduce the level of corruption in the public sector. For example, according to the E-Government Development Index (EGDI) of the United Nations E-government Survey-2014 (United Nations Department of Economic and Social Affairs, 2014) most of the public-sector corruption exists in the governments' procurement activities and they have reduced successfully through the implementation of e-governance in countries such as Australia, Canada, Singapore, Republic of Korea etc.

As a further step of its e-governance policy Sri Lanka introduced the Citizens' Charter in 2008 (Public Administration Circular No. 05/2008, Ministry of Public Administration and Home Affairs, 2008)

which positively encourages public organizations to be more responsive to the public. Furthermore, due to its e-procurement services, the relationship with the private sector has increased and there is a discernible reduction in the corrupt practices such as accepting bribes, nepotism, concealing merit-based competitions, undue delays, etc.

The Sri Lankan government has made significant progress towards enhancing online portals and as a result is currently ranked the 79th in the world and the first in South Asia. It is within the top 20 countries in Asia according to the United Nations E-government Survey 2016 (United Nations Department of Economic and Social Affairs, 2016). Its e-government policies have expanded to all segments of the population by offering services to everyone. According to the E-Government Development Index (EGDI), countries are grouped into four categories. Table 02 depicts how Sri Lanka and other South Asian Countries are grouped according to this index.

Table 2: South Asian Countries grouped by EGDI-2016

Very High (EGDI) More than 0.75	**High (EGDI) Between 0.50 and 0.75**	**Middle (EGDI) Between 0.25 and 0.50**	**Low (EGDI) Less than 0.25**
-	Sri Lanka	India	Afghanistan
-		Maldives	
-		Bangladesh	
-		Bhutan	
-		Nepal	
-		Pakistan	

(Source: United Nations Department of Economic and Social Affairs, 2016: 109).

Issues of e-governance in Sri Lanka

Sri Lankan society displays a distance of power between different social groups (Hofstede, 2010). It can be seen at different levels such as between political representatives, bureaucrats, common people as well as government and private sector stakeholders. This societal gap has led to corruption due to lack of communication, less competition and transparency. The bureaucrats enjoy an increase in their power

over the people that results from the rigid laws and regulations. For example, tax inspectors or regulators have higher incentives to engage in corrupt practices (Iqbal and Seo, 2008: 59). The Sri Lankan e-culture is yet to transform the traditional characteristics of bureaucracy into a citizen-friendly good service delivery system.

Though Sri Lanka comparatively scored high in the Corruption Perception Index (CPI) as depicted in the following table, it is an open secret that there is widespread of corruption in Sri Lanka among high ranking government officials, politicians and others in the higher echelons of power (Transparency International, 2013). Thus, much of the central level development project planning and implementation fail to provide a picture of certainty for the common people who do not have access to information on the short and long-term outcomes, the sponsors and the negotiation process. By and large, the government has still failed to establish a machinery to prevent corruptions that exist in the higher levels of the development scenario.

Table 3: Corruption in the Public Sector: Country Ranks & Scores

Name of the Country	**Rank**	**Score**
Sri Lanka	91	37
India	94	36
Bangladesh	136	27
Nepal	116	31
Pakistan	127	28
Afghanistan	175	08
Bhutan	31	63

(Source: Transparency International, 2013).

Though e-culture plays a vital role in curbing corruption at different levels of the public-sector institutions, many of the traditional administrators resist the new culture. They appear to be reluctant to perceive new technologies and do not believe in the functions of the electronic tools. Therefore, it has mostly resulted in wastage of public funds.

Moreover, a continuous process to maintain and update the services of the electronic infrastructure facilities in many public-sector institutions cannot be seen and this situation endangers the continuation of e-government policies resulting in unregulated corruption. On the other hand, public officials tend to be more involved in purchasing activities by highlighting the need of electronic equipment than putting them for right usage. Purchasing is the main path leading to corrupt practices involving the role of a middleman between the buyer and seller. This is a highly recognized corrupt practice in the local government institutions of Sri Lanka (Kanchana, 2016: 10). Public officials often use the breakdown of technology as an excuse to avoid their duties properly and to delay public services to the people. Due to the discontinuation of the usage of electronic tools, sometimes, most of the essential data may be lost prior to the auditing activities and, thus, those situations have led to a high degree of corruption.

It is not easy to measure the degree to which extent the discretion power can be used by a public official. It occasionally depends on the seniority, experiences, organizational and personal values, etc. When a public official tends to use discretion power for gaining personal benefits, there should be a proper machinery to track it. Most of the developing countries like Sri Lanka are suffering from a lack of control of the discretion of power of the government officials. Because of this discretion of government officials, especially, those who are attached to the security forces, most of human rights violations can be seen. When people try to find solutions for their injustices, monopoly of power of the government is used to dominate the processes and procedures.

Further, at the lower level of administration there is a high level of corruption; for instance, the field officers working on the issues of lands, revenue collecting, road cleaning, town maintenance etc. It is not easy to prevent corruption-related activities through e-governance. Delaying and unnecessary bargaining for deliveries of services also cause corruption. Such illegal practices are very much found among village level public officials such as *Grama Niladhari, Samurdhi* Officer and Technological Officers, etc. Further, corrupt practices can be seen not only at the point of delivery of public services but also at the decision-making levels, between political

representatives and public officials. In such instances e-governance has failed to curb corruption in Sri Lanka.

E-governance in Sri Lanka is challenged due to various factors such as lack of well-trained public officials and inadequacy of supervision done by the expert panels on technology, and inadequate alternative solutions for frequent failures of technology and lack of regular training of public sector officials on trouble-shooting the system errors which occur when online services are provided to the public and the heavy workload of public officials of many of the provincial level institutions. When there are overburdening pressures on duties which are not properly defined, public officials are unable to maintain continuous updates on online services. That overburdened work environment influences further corrupt practices.

There is still a gap between central and provincial level public administration. The implementation of e-governance has not bridged that gap totally. E-governance through ICT should not only be available for the central government activities but it should be available for the provincial level activities as well. Unavailability of equal access to e-governance by all the citizens of the country is a major repercussion of the digital-divide which needs to be addressed with careful consideration on the income level of the people. Also, there should be a linking process through e-practices to prevent overlapping of public services. Though there are many activities which can be done as paperless e-services, public officials do not have enough confidence to be adaptive with them due to inadequate technological support.

Nevertheless, it is not possible to ensure e-governance without the implementation of the Right to Information Act (RTI). Gartner's E-governance Maturity Model shows the major phases of e-governance as a process and implementation of those phases in Sri Lanka suffered a lot because of the lacks in right to access information. The Act was enacted in 2016 and a proper implementation mechanism is yet to be found. Because of the delay of its proper implementation, most of the civil society organizations, media channels and common people have not been able to receive proper e-governance services. Moreover, this kind of lacks in disclosure of information facilitates corruption at the higher levels of decision making. However, in the future, the Right to Information Act, No. 12 of 2016 (Democratic

Socialist Republic of Sri Lanka, 2016) will facilitate the implementation of the 2nd, 3rd and 4th phases of e-governance maturity model.

The active participation of people in decision making and implementation in Sri Lanka is still a myth. Though there are online channels to convey the messages to public institutions, people know that those channels are only for display purposes. An interactive system which accepts people's feedback positively and considers them as serious matters requiring urgent attention is necessary for a transparent democratic process. In a way, it can be argued that the Public-Private Partnership is the main way to achieve e-governance targets and to avoid the difficulties caused due to technological and other shortcomings of the government. The government has not yet fully tested its capability or opened enough access to private stakeholders either. Therefore, many of the technological barriers, threats, inefficiencies can be seen in e-governance of Sri Lanka.

Conclusion

The use of e-governance in curbing corruption can be considered as a partial tool and is not a comprehensive solution to reduce the monopoly of the government. Political commitment is a must to the successful implementation of ICT. Sri Lanka's e-governance policy suffers considerably since it lacks a strong political commitment and due to prevalence of administrative malpractices. The administrative malpractices refer to the characteristics such as "resistance to change, rigid adherence to rules, reluctance to delegate authority, sycophancy toward superiors, "target" mentality, indifference to the standards of efficiency, ignorance of the purposes behind regulations, generalist-elitist orientation combined with hostility toward technology, overstaffing, corruption, xenophobia, and nepotism" (Caiden,1991:488). Sri Lanka's administrative culture still has not deviated from these negative qualities. E-governance is the main alternative solution to curb corruption and it needs time to be established within the society. The role of e-governance in curbing corruption depends on the success of its institutional establishment to the political system. It cannot address corruption directly and its first role is to change the societal mindset into e-culture. However, in

general, e-governance plays an important role in curbing public-sector corruption and it has demonstrated successful outcomes in comparison to other public-sector reforms in Sri Lanka.

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Quantification of Pesticide Residues in Selected Vegetables using the QuEChERS Method

Meragal Kulathilakage Lasanthi Kumari Rajapakse[1] Nimsha Sevwandika Weerakkody[1*] Pulippu Widana Yoshida Lakshani[2]

[1]Department of Agricultural and Plantation Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nawala, Sri Lanka
[2]Office of Registrar of Pesticides, Gatambe, Peradeniya, Sri Lanka

Abstract

Pesticide residues in fruits and vegetables have become a major problem in Sri Lanka. Therefore, there is a need to optimize the Quick, Easy, Cheap, Effective, Rugged and Safe (QuEChERS) method to determine pesticide residues in fruits and vegetables and assure the safety of food. The objectives of this study were to optimize the method for multi-residue pesticide analysis, to develop calibration curve to detect concentration of pesticides and to determine prevalence of five pesticide residues in locally grown vegetables tomato, cabbage and capsicum in Puttalum, Dambulla and Nuwara Eliya districts. Pesticide residues were determined by Gas Chromatography with Mass Spectrometry after multi residue extraction procedure (QuEChERS method). The QuEChERS method was validated using five pesticides named Diazinon, Chlopyrifos, Fipronil, Prothiofos and Tebuconazole and their retention times in minutes were15.948, 19.566, 20.342, 22.308, and 26.201 respectively. Coefficient of detection was obtained near 0.99 for all

**Correspondence should be addressed to Dr. N. S. Weerakkody*
Email: *nweer@ou.ac.lk*
https://orcid.org/0000-0003-3351-1889

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tested standard pesticides confirming the accuracy of the test method. Out of 45 vegetables samples, 15 samples were detected with pesticide residues, either Chlopyrifos, Prothiofos or Tebuconazole. However, pesticide residual values were less than Maximum Residual Levels for all the tested pesticides. Tebuconazole was the mostly detected pesticide residue with 0.128 ppm and 0.052 ppm in tomato and cabbage collected from Matale and Puttlum districts respectively. Therefore, it is important to collect samples while obtaining farmer details including the type of pesticide applied, harvesting interval and frequency and application rate of pesticide for further study.

Key Words: Pesticide residues, vegetables, Gas Chromatography-Mass Spectrometry, QuEChERS

Introduction

Vegetables are cultivated as seasonal and non-seasonal crops, mainly in the Yala and Maha seasons in Sri Lanka. Some areas of Nuwara Eliya and Kalpitiya grow vegetables in more than two seasons practicing intensive cultivation methods. Fresh vegetables are good a source of vitamins, minerals, fiber, and antioxidants. Therefore, vegetables have high demand throughout the year. With the green revolution, farmers are shifting from traditional varieties to cultivate high-yielding new-improved and hybrid varieties. Most of these varieties are highly vulnerable to pest and diseases. Therefore, farmers tend to use more pesticides. Most pest control strategies heavily depend on the type of pesticides used. Pesticides are chemical substances applied to crops at various stages of cultivation and during the post-harvest storage of crops. The use of pesticides is intended to prevent the destruction of food crops by controlling agricultural pests or unwanted plants and to improve plant quality (Gözde *et al*, 2014). Pesticides used in agriculture include insecticides, fungicides and herbicides. Pesticides are applied to crops throughout the world but they can be toxic and can thus be harmful to human health. More than 800 pesticides belonging to over 100 different chemical classes are used (Camino *et al*, 2011). In vegetable production, insecticides are used to control pest and fungicides to control diseases. In the Sri Lankan context, pesticides are directly applied to crops and some may still be present as residues in the vegetables after their harvest.

Human intake of toxic substances due to pesticide residues in food commodities can be much higher than the intake of pesticide substances related to water consumption and air inhalation (Ewa *et al.* 2015). As food safety is among the first priorities in many countries, there is an increasing need for the determination of pesticide residues in various food commodities. The detection of pesticide residues in conventional food has important implications in the rational development and proper use of chemical pesticides, protecting the environment, human health, improving the quality and assuring the safety of agricultural produce by avoiding international trade disputes (Yan-Fei *et al*, 2014). A pesticide residual level in food has become a major problem worldwide due to their direct implication on human health and international trade (Blankson *et al*, 2016). The residual analysis of fruits and vegetables is an important requirement and responsibility for all food authorities to prevent toxic chemicals entering our bodies through the food chain. For toxic residual levels detection of pesticides in fruits and vegetables advance spectroscopic instruments like Gas Chromatography with Mass Spectrometry (GC/MS), Liquid Chromatography with Mass Spectrometry (LC/MS) are important. The pesticide residual detection method needed to be a Quick, Easy, Cheap, Effective, Rugged and Safe (QuEChERS) method which can be optimized for individual requirement. Yan-Fei Li *et al* (2014) developed QuEChERS with magnetic Nano particles gas chromatography tandem mass spectrometry to remove impurities and enhance the purifying effect. Further, Koesukwiwat *et al* (2011) developed the fast-low pressure gas chromatography triple quadrupole tandem mass spectrometry method. However, these sophisticated equipment are not available in Sri Lanka, hence the requirement for a quick, easy and safe methods which can be easily used in low-middle income countries.

The demand for organically grown food crops is expected to increase significantly in the years ahead as consumers become more concerned about pesticides residues in the human diet (Tietz, 1990). Diazinon, Chlopyrifos, Fipronil, Prothiofos and Tebuconazole are the most commonly used pesticides in Sri Lanka (Sumith 2005; DOA 2011, 2012, 2013, 2014, 2015). Therefore, there is a need to determine pesticide residues in fresh vegetables related to organophosphorus (OPP) mainly used in agriculture.

The aim of this study was to investigate the pesticide residues in selected vegetables which have been collected from Nuwara Eliya, Matale and Puttalum markets. Pesticide residues were determined by Gas Chromatography with Mass Spectrometry (GC/MS). A multi-residue method QuEChERS was developed and described for simultaneous determination of five pesticides commonly used in crop protection.

Materials and Method

Preparation of standards and calibration curves Stock solutions (500 mg/L) of Diazinon, Chlopyrifos, Fipronil, Prothiofos and Tebuconazole standards were prepared for the calibration of GC/MS (Sigma Aldrich, Germany). Pure standard taken out of the refrigerator (2-8 °C) and kept at room temperature till the standard reached the room temperature. Each standard 25 mg was weighted into 50 ml volumetric flask and volume was adjusted with HPLC grade acetone (Sigma Aldrich, USA). Labeled bottles were stored in the refrigerator at 4-6 °C.

Intermediate stock solution 50 mg/L was prepared by transferring 5.0 ml stock solution by using 5 ml bulb pipette into 50 ml volumetric flask and adjusted with HPLC grade acetone.

Primary working standard solution 5 mg/L was prepared by transferring 5.0 ml from each intermediate stock solution by using 5 ml bulb pipette into same 50 ml volumetric flask and the volume adjusted with HPLC grade acetone. Calibrations working standard concentrations 0.2, 0.5, 1.0, 1.5 and 2.0 mg/L were prepared into 10 ml volumetric flask. The level of detection (LOD) and recovery percentage were calculated as follows.

LOD = Lowest calibration level x final volume/weight use (per sample)

Recovery % = Calculated concentration/spiked concentration *100

Sample Collection

The locally grown vegetable sample of 1 kg was collected from local markets as presented in Table 1. All samples were immediately freeze-dried and stored in a deep freezer at - 20 °C until analysis.

Table 1: - Locations of the vegetable samples collected from different districts

District	Location	Field type	Vegetable
Nuwara Eliya	SithaEliya	Market	Cabbage, Capsicum,Tomato
	Shanthipura	Market	Cabbage, Capsicum, Tomato
	Kandapola	Market	Cabbage, Capsicum, Tomato
	Labukele	Market	Cabbage, Capsicum, Tomato
	Hanguranketha	Market	Cabbage, Capsicum, Tomato
Matale	Dambulla	Market	Cabbage, Capsicum, Tomato
		Market	Cabbage, Capsicum, Tomato
		Market	Cabbage, Capsicum, Tomato
		Market	Cabbage, Capsicum, Tomato
		Market	Cabbage, Capsicum, Tomato
Puttalam	Norochchole	Market	Cabbage, Capsicum, Tomato
	Mampuri	Market	Cabbage, Capsicum, Tomato
	Puttalim	Market	Cabbage, Capsicum, Tomato
	Kalpitiya	Market	Cabbage, Capsicum, Tomato
	Anamaduwa	Market	Cabbage, Capsicum, Tomato

Sample Preparation

The laboratory samples of freeze-dried vegetables were thoroughly homogenized. Approximately 10 g sample was taken into a polypropylene centrifuge tube (50 mL) and the 100 µl and 200 µl of the 5.0 mg/L spiking mixture was added separately. The extraction procedure was followed as Gözde*et al*, (2014) and AOAC (2011) for the determination of pesticide residues based on fruits and vegetables by acetonitrile extraction and partitioning with magnesium sulphate. Acidified acetonitrile 10 ml was added into each tube and the content was shaken using vortex. Subsequently, the content of the salt kit was added. The mixture was immediately shaken for 1 min and centrifuged at 3000 rpm for 3 min. Afterwards total amount of acetonitrile fraction was transferred to 15 ml polypropylene tube containing 1200 mg of Magnesium Sulfate, 400 mg PSA (Primary Secondary Amine) and 400 mg of GCB (Graphitized Carbon Black).

The tube was vortexed for 1 min and centrifuged at 4000 rpm for 4 min. Finally total volume aliquot of the supernatant was transferred into glass round bottom flask and totally dried under nitrogen. Acetone 2 ml was added and dissolved in all the dried compounds and filtered through 0.45 µm PTFE filter. Content was transferred into glass auto sampler vial.

GC/MS Analyses

Gaschromatography analysis was conducted on Agilent DB-35ms GC capillary Column, (30 m x 0.25 mm, 0.25 µm) with the following conditions: Helium was in constant flow mode, 2.0 ml/min; initial inlet temperature 80 °C ramp to 300 °C , with 8 min solvent delay, injection volume 1 µl with split less (20:1 split ratio), oven temperature program 80 (1 min), 10 °C/min to 160 °C (1 min), 6 °C/min to 250 °C (1 min), 10 °C/min to 300 °C (2 min). Source, Quadruple and transfer line temperature were 230 °C, 150 °C and 300 °C respectively. The Mode SIM (Selected Ion Monitoring) and Multiplier Voltage were the Auto Tune Voltage.

Standards were injected to GC/MS continuously for three days with a proper sequence for validation of GC/MS. After completing the validation process calibration curves were prepared for five pesticides. Then samples were injected to GC/MS.

Data Analysis

The quantitative residual values of Chlopyrifos, Diazinon, Fipronil, Prothiofos and Tebuconazole were reported using appropriate units as milligrams per kilograms (mg/kg) or ppm

$$\textbf{Amount of Pesticide} = \frac{\textbf{Concentration of sample solution (mg/µl)} \times \textbf{2ml} \times \textbf{1000 µl)}}{\textbf{Sample weight (g)} \times \textbf{1000 (mg)}}$$

Results and Discussion

Validation Results

Retention times for each pesticide standard were obtained for the validation of the method. Retention times for calibration standards are shown in Table 2.

Table 2. – Retention times for calibration chemical standards

Calibration Standard	Retention Time (RT)	Coefficient of Detection (r^2)	LOD with Uncertainty (mg/kg)	Average recovery (%)
Diazinon	15.946	1.0000	0.04 ± 0.0061	85.81
Chlopyrifos	19.565	0.9980	0.04 ± 0.0067	86.58
Fipronil	20.353	0.9960	0.04 ± 0.0065	82.56
Prothiofos	22.308	0.9990	0.04 ± 0.0063	85.05
Tebuconazole	26.179	0.9980	0.04 ± 0.0064	82.91

The level of detection for all the pesticides was:
0.2x 2/10=0.04 ppm or 0.04 mg/kg.
The average recovery percentage was: 82.56 - 86.58%.

Chromatogram for the five selected pesticides is showed in Fig.1. Different retention times were obtained for 5 different standard pesticides. The following standard pesticides peaks with their retention times were considered for the analysis of pesticide residuals of market sample analysis.

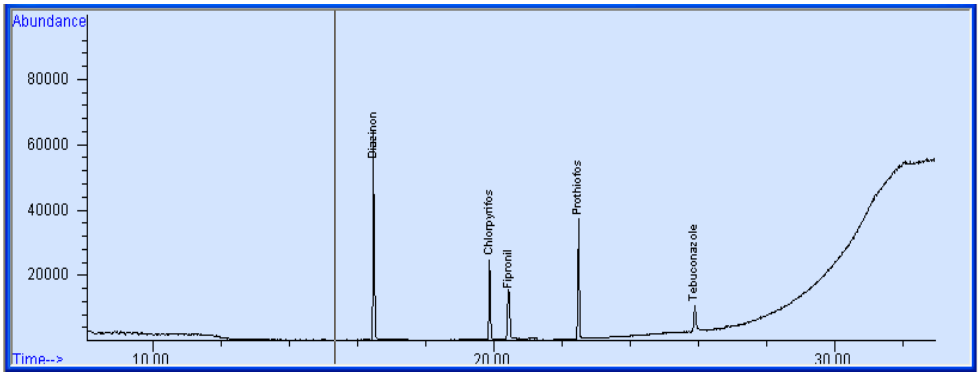

Figure1. Chromatogram for 5 selected standard pesticides

Pesticide Residue Levels in local vegetables in selected areas
Pesticide residue levels of selected vegetables from Nuwara Eliya, Matale and Puttalam districts are shown in Table 3, 4 and 5

Table 3. Pesticide residues in vegetables from the Nuwara Eliya District

Sample No.	Vegetable	Diazinon	Chlorpyrifos	Fipronil	Prothiofos	Tebuconazole
ROP/RV/16/200	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/201	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/202	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/353	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/488	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/203	Cabbage Cabbage	ND	ND	ND	ND	ND
ROP/RV/16/204	Cabbage Cabbage	ND	ND	ND	ND	0.052 ppm
ROP/RV/16/205	Cabbage Capsicum	ND	ND	ND	ND	0.052 ppm
ROP/RV/16/354	Capsicum Capsicum	ND	ND	ND	ND	ND
ROP/RV/16/489	Capsicum Capsicum	ND	ND	ND	ND	ND
ROP/RV/16/206		ND	ND	ND	ND	0.054 ppm
ROP/RV/16/207		ND	ND	ND	ND	ND
ROP/RV/16/208		ND	ND	ND	ND	ND
ROP/RV/16/355		ND	ND	ND	ND	ND
ROP/RV/16/490		ND	ND	ND	ND	ND

Tebuconazole was detected in only 2 cabbage samples and a capsicum sample out of 15 vegetable samples analyzed from the Nuwara Eliya district. The residue content of tebuconazole in cabbage was 0.052 ppm and 0.054 ppm in capsicum. However, MRL of cabbage for tebuconazole was 1 mg/kg /1ppm (CODEX Alimentarius).

Table 4. Pesticide residues in vegetables from the Matale District

Sample No.	Vegetable	Diazinon	Chlorpyrifos	Fipronil	Prothiofos	Tebuconazole
ROP/RV/16/370	Tomato	ND	ND	ND	ND	0.128 ppm
ROP/RV/16/371	Tomato	ND	ND	ND	0.068 ppm	ND
ROP/RV/16/372	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/373	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/374	Tomato	ND	ND	ND	0.068 ppm ND	ND
	Cabbage	ND	ND	ND		ND

ROP/RV/16/ 375	Cabbage	ND	ND	ND	ND	ND
ROP/RV/16/ 376	Cabbage	ND	ND	ND	ND	ND
ROP/RV/16/ 377	Cabbage	ND	ND	ND	ND	ND
ROP/RV/16/ 378	Cabbage	ND	ND	ND	ND	ND
ROP/RV/16/ 379	Capsicum	ND	ND	ND	ND	ND
ROP/RV/16/ 380	Capsicum Capsicum	ND	ND	ND	ND	0.104 ppm
ROP/RV/16/ 381	Capsicum Capsicum	ND	ND	ND	ND	ND
ROP/RV/16/ 382		ND	ND	ND	0.068 ppm	ND
ROP/RV/16/ 383		ND	ND	ND	ND	0.108 ppm
ROP/RV/16/ 384						

Results showed that the prothiofos was detected in two tomato samples with 0.068 ppm and one capsicum sample having 0.068 ppm. While tebuconazole was detected in one tomato sample with 0.128 ppm and two capsicum sample with 0.104 ppm and 0.108 ppm respectively among 15 vegetable samples analyzed from the Matale district. However, MRL of tomato for tebuconazole was 0.7 mg/kg or 0.7 ppm (CODEX Alimentarius).

Table 5. Pesticide residues in vegetables from the Puttalam District

Sample No.	Vegetable	Diazinon	Chlorpyrifos	Fipronil	Prothiofos	Tebuconazole
ROP/RV/16/ 303	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/ 304	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/ 305	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/ 306	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/ 307	Tomato	ND	ND	ND	ND	ND
ROP/RV/16/ 308	Cabbage	ND	0.048 ppm	ND	ND	ND
ROP/RV/16/ 309	Cabbage	ND	ND	ND	ND	0.052 ppm 0.052 ppm
ROP/RV/16/ 310	Cabbage	ND	ND	ND	ND	ND
ROP/RV/16/ 311	Cabbage	ND	ND	ND	ND	0.052 ppm ND
ROP/RV/16/ 312	Cabbage	ND	ND	ND	ND	0.052 ppm
		ND	ND	ND	ND	ND

ROP/RV/16/313	Capsicum	ND	ND	ND	ND	ND
ROP/RV/16/314	Capsicum	ND	0.048 ppm	ND	ND	ND
ROP/RV/16/315	Capsicum	ND	ND	ND	ND	
ROP/RV/16/316	Capsicum	ND	ND	ND	ND	
ROP/RV/16/317	Capsicum					

The data of Table 5 showed that the chlorpyrifos was detected in one cabbage sample with one capsicum sample having the same amount of 0.048 ppm. Tebuconazole content 0.052 ppm was detected in three cabbage samples and one capsicum sample among 15 vegetable samples analyzed from the Puttalam district. Interestingly, Tebuconazole in cabbage and tomato samples did not exceed the MRL 1.0 ppm and 0.7 values respectively specified by CODEXs. Similarly, Tebuconazole in tomato did not exceed the global MRL 1.3 ppm and EU MRL 0.9 ppm as specified. However, MRLs for other pesticides for cabbage, tomato and capsicum were not found in the relevant literature except as shown in Table 5 for the comparison of our data. None of the tested samples showed the presence of Diazinon chemical residue. We did not detect chlorpyrifos in our tested tomato samples from the three different districts, Amadoudiop *et al* (2016) reported the presence of higher chlorpyrifos residuals 0.037 ppm and 0.05 ppm in tomato collected from Camberena and Malika of Niayes Zone Senegal. Chlorpyrifos was only detected in 2 samples of cabbage and capsicum with a figure below MRLS 0.048 ppm level found in the Puttalam district out of 45 samples tested in our study. However, according to Blankson *et al* (2016) chlorpyrifos was reported as the most frequently identified pesticide residue in 14% of the vegetables collected from the market Accra, Ghana.

Table 6. Different MRL data

	Cordex MRL			**Global MRL**			**EU MRL**		
	Toma	**Capsi.**	**Cabb.**	**Toma.**	**Capsi.**	**Cabb.**	**Toma.**	**Capsi.**	**Cabb.**
Diazinon	0.5	-	0.5	-	-	-	0.01	-	0.05
Chlorpyrifos	-	-	1	-	-	1	0.01	-	0.01
Fipronil	-	-	0.02	-	-	-	-	-	-
Prothiofos	-	-	-	-	-	-	-	-	-
Tebuconazole	0.7	-	1.0	1.3	-	-	0.9	-	-

Most of the experiments conducted worldwide interpreted the residue levels in the tested samples up to micro or nano gram per kg or mL level. Anastassiades *et al* (2007) showed that the limit of detection was up to ppb level and Nano gram/g level using the advances GC/MS, EI/MS and CI/MS. In the present experiment we used GC/MS which has a single quadruple, and which could detect a minimum of 0.04 ppm level, even though detected residue levels in the tested samples were below than the standard MRLs.

Conclusion

Multi residue methodology showed to be very simple and rapid, requiring small sample sizes, minimizing solvent consumption resulting in low amount of hazardous waste. The utilization of Mass Spectrometric detection provided both quantitative information and confirmation of pesticide residues in cabbage. Out of 45 samples collected from three different districts, 15 samples detected significant values for Chlorpyrifos, Prothiofos and Tebuconazole. These values did not exceed MRL levels for cabbage and tomato.

For the purpose of this study samples were collected from markets where the sample origin was not known. Therefore, details of the farmers, occurrence of pest and disease and spectrum of pesticides usage, pre-harvest interval, and fertilizer usage are unknown. For further research purposes, samples should be collected from known sources where such details could be obtained. Moreover, there is a need to test samples for all possible pesticides.

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Price Elasticity of Demand for Pipe-Borne Water: A Pre-Requisite for Solving the Water Problem in the Colombo City

Roshen Fernando[1]*, SP Premaratne[2]

[1,2]Department of Economics, University of Colombo, Colombo 3, Sri Lanka

Abstract

Water problem in the Colombo city has aggravated over the time. Thus, encouraging consumers for responsible water consumption is imperative. As the city is almost completely reliant on pipe-borne water, water tariff could be utilized in this effort. However, as water is a basic need and a human right, an upward revision of tariff should not deprive consumers from satisfying essential needs, while discouraging wasteful consumption. Therefore, this study attempted to identify whether the consumers are sensitive to changes in water tariff, whether there exists a disparity among different blocks of tariff with respect to Price Elasticity of Demand and identify different sensitivities of levels of consumption to an increase in tariff.

In order to achieve the research objectives, the Price Elasticity of Demand for pipe-borne water, overall and block-wise, was analyzed, before and after the last revision of tariff in 2012. Results revealed that after the revision, overall consumption had reduced and out of nine blocks, first three and last two were the least sensitive and the

**Correspondence should be addressed to Mr. Roshen Fernando. Department of Economics, University of Colombo.*
Email: *wbrpsfdo@gmail.com*
https://orcid.org/0000-0001-5245-6702

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four blocks in the middle were the most sensitive. Thus, it was recommended that in order to discourage wasteful consumption, unit rates of highly sensitive blocks should be increased and to preserve economic efficiency and welfare, the tariff for least sensitive blocks should not be revised significantly.

Keywords: Price Elasticity of Demand, Pipe-borne Water, Water Tariff, Domestic Consumers

Introduction

The water problem in the Colombo city, the commercial capital of Sri Lanka, has been created by rapid urbanization, increase in population, change in climatic conditions, problems related to operational efficiency and increased pollution and depletion of water sources. This has, in turn, resulted in several issues, including those related to health and sanitation and water stress in the city. As the Colombo city continues to develop and become a strategic hub for Asia, it is of utmost importance to combat the water problem. As the Colombo city is almost covered with pipe-borne water, one of the major solutions to reduce the magnitude of the problem is to encourage consumers to use the resource responsibly, via awareness raising and revision of tariff.

Moreover, an upward revision of tariff would also enable National Water Supply & Drainage Board (NWSDB), the main authority instrumental in provision of water for the Colombo city, to increase its operational income and reduce reliance on government grants and soft loans. Furthermore, this would enable NWSDB improve its service, reducing operational inefficiencies.

However, due to socio-economic and political sensitivities attached to water, a revision in tariff is, generally, heavily resisted by the society and could lead to social unrest. Thus, prior to revision of tariff, it is of utmost importance to understand which levels of consumption are more sensitive to changes in price, thus, indicative of wasteful or preventable consumption, and which levels of consumption are less sensitive to changes in price, thus, indicative of essential consumption. Additionally, this would help achieve the broader goals

of tariff revision, such as encouraging responsible use of the resource and preserving economic efficiency and welfare.

Nevertheless, it was observed that the recent attempt of NWSDB to revise tariff was heavily opposed by the masses, largely due to the absence of evidence as to how the revision has been formulated. Thus, had a study of this nature been performed, the justification for revision would have been made stronger. Considering the necessity of such research, this study was conducted to establish whether the demand for pipe-borne water in the Colombo city is responsive to changes in tariff, if it is responsive, whether there is a disparity among the blocks of consumption with respect to Price Elasticity and if there exists a disparity, which blocks of consumption are more or less responsive to changes in price.

Review of Literature

Price Discrimination

According to Niels et al. (2011), price discrimination is pricing the same product differently even though the price differentials do not reflect any cost differential. The most frequently-used classification of price discrimination has three types, referred to as first, second and third-degree price discrimination. Exploiting the maximum Willingness to Pay of each individual customer is referred to as first-degree price discrimination; charging differently for different quantities consumed is referred to as second-degree price discrimination and different customer segments being charged differently is referred to as third-degree price discrimination (Cabral, 2005).

Water Tariff Structures

Objectives of Water Tariff

According to Boland & Whittington (2000), water tariff should ensure revenue sufficiency for the service provider, economic efficiency for the users, equity and fairness, income redistribution and resource conservation. Additionally, Rogers et al. (2002) emphasizes on holistic sustainability as an important objective of water tariff.

Design of Water Tariff Structures

According to Brannon (2017), the choice of a tariff structure is dependent upon factors including water availability, income of the consumers, intended purpose and levels of usage and socio-economic situations.

An ultimate structure could be inducing uniform charges, block, seasonal, peak, conservation or capacity rates. The commonly-used structures incorporate two-part tariff structure, where both flat and volumetric rates would be present.

The widely-used volumetric tariff structures would include a purely proportional component to the consumption and either increasing or decreasing block tariffs with variable or fixed bands.

Water Problem

According to Department of Interior, United States (1966), a water problem is essentially a concern about not having the adequate quantity of water of adequate quality, at a reasonable cost, when and where needed. According to this definition, few reasons for a water problem can be identified. If either water is not obtained in adequate quantity, quality at the right time and place or even if the price charged for water or cost borne in obtaining water is not affordable, then, there deemed to be a water problem.

According to NWSDB (2017), in assessing the quality of pipe-borne water there are two components considered as product and service components. The product component includes parameters, such as the quality of water received by a consumer, quantity of water demanded and received by the consumer, timely receipt of water and adequate pressure with respect to water received. The service component includes parameters, such as timely receipt of accurate bills, timely update of accounts, convenience of payments, advance and adequate notice of interruptions and productive responses to complaints.

Thus, combining both the definition of water problem and parameters of quality of pipe-borne water, it can be stated that absence of any of the product or service parameters will result in a water problem for consumers, depending on pipe-borne water provided by NWSDB.

Water Problem in the Colombo City: Nature, Causes and Consequences

According to the Department of Census and Statistics (DOCS) Sri Lanka (2015), the population in the Colombo city is 561,314. However, being the commercial capital of Sri Lanka, it records a much higher total population due to the daily mobile population approximated at 1.9 million (Ministry of Megapolis and Western Development, 2017). According to NWSDB (2017), the Colombo city is almost totally covered with pipe-borne water. However, still a number of water problems are faced by the population in the Colombo city (Bandara, 2003).

According to Letchumanamohan (2014), the problems faced by the consumers in the Colombo city with respect to obtaining of pipe-borne water include insufficient pressure in the pipe distribution system, non-availability of water for 24 hours, inaccurate meter reading, delays in attending to repair work and poor quality of repairs leading to constant interruptions and leakages. Accordingly, it can be observed that these conditions satisfy the determinants of water problem and thus, it can be deemed that there exists a water problem faced by existing consumers in the Colombo city.

In addition to the water problem from the perspective of existing consumers, there exist few broader water problems for the Colombo city on the whole. According to Fernando (2014), non-revenue water in the Colombo city accounts approximately to 54% of the provision, and it hence, prevents the authority obtaining the right revenue and threatens the financial sustainability of the provision.

Furthermore, according to Gamini (2015) and Bandara (2003), increased pollution of water resources, such as those caused by industrial and domestic effluents, create critical challenges for NWSDB to provide water of the right quality demanded by the consumers and stipulated by World Health Organization continuously. Additional purification of water has resulted in additional costs for the authority, in turn compromising its financial sustainability. In situations where NWSDB has not been able to totally contain the damages, the risks to health of consumers have risen.

In addition to that, according to Warakapitiya and Shankar (2017), excessive consumption of water by the ongoing construction projects in the Colombo city has led to reduction in pressure and quantity available for consumption by other existing consumers.

Moreover, according to Lanka Business Online (2017), the combination of climatic changes leading to dry weather and increase in population has led to an overall increase of 15% in water consumed by existing consumers in the Colombo city, making it further challenging for NWSDB to secure the right quantity and provide water throughout at the right pressure. The increased administration and other related charges have not been covered by the price charged, and accordingly, the service is not any longer financially sustainable for NWSDB.

In a much broader sense, the water problem in the Colombo city and Sri Lanka, on the whole, has been created by rapid urbanization, water scarcity and degradation, absence of inter-sector governance, lack of operational efficiency, lack of investment in the water sector and absence of incentivizing tariff structure for water conservation. These, in aggregate, have led to a number of problems, including inability to provide the right quantity of water of the right quality at the right price and time and maintaining the right service level, and have created a water problem in the Colombo city (Fan, 2016).

Due to the water problem in the Colombo city, a number of consequences, such as spreading of both water-borne and water vector habitat diseases, overall decline in sanitation of the population and risk of NWSDB not being financially viable have arisen (Fan, 2016).

Potential Solutions for the Water Problem in the Colombo City

Fan (2016) has proposed increasing operational efficiency, encouraging consumers to conserve water, increasing monitoring and regulation in order to prevent pollution of water resources, improving water sector governance and increasing investments in water sector and increasing financial sustainability of NWSDB in order to address the causes of the water problem.

Why Revision of Tariff & Price Elasticity of Demand?

According to the potential solutions, proposed by Fan (2016), one of the ways of addressing the water problem in the Colombo city is ensuring that NWSDB has sufficient financial and non-financial resources to cater to the demand for pipe-borne water fully without interruptions. In order to achieve this, while the government could empower NWSDB via grants, NWSDB too can utilize its tariff structures to obtain a cost-reflective charge from consumers. The current practice is to cover the operation and maintenance cost, in whole, and part of the investment cost, via a two-part, increasing block tariff scheme (NWSDB, 2017). This implies that with the rising operational and maintenance costs the tariff structure needs to be revised.

Moreover, one of the objectives of the utility tariff structures is to encourage consumers to use the utility responsibly and conserve it (Rajput, 2007). This objective would not be achieved if the tariff levied falls to an insignificant percentage of total disposable income of a consumer (Feenstra and Taylor, 2008). Accordingly, it is observed that the tariff structure needs to be revised from time to time to an acceptable level, without compromising the economic efficiency, to encourage consumers to preserve water.

NWSDB implemented its last tariff structure revision in October 2012. It is now underway to revise the tariff structure again to reflect the service level (NWSDB, 2017). However, the proposal to revise tariff structure is heavily opposed by the consumers and society, due to the concerns related to loss of economic efficiency and affordability. Two tools that could have been utilized in this effort to ensure perseverance of economic efficiency and affordability are an affordability analysis and a demand elasticity analysis with respect to price. Especially, an assessment of price elasticity of demand would enable to identify the level of consumption essential for consumers and levels of wasteful consumption, as with increase in price, a potential deviation towards conservation can be expected (Bishop and Weber, 1996).

Previous Methodologies

Conley (1967) in Southern California for multiple sources; Katzman (1977) in Penang, Malaysia for domestic water; and Cairncross and Kinnear (1992) in Khartoum, Sudan for domestic water had established the price elasticity of demand for water using time series data. Young (1973), too, had assessed the price elasticity of demand for municipal water in Tucson, Arizona using statistical techniques and attempted to predict the changes in demand with changes in price using regression analysis.

Howe (1982), however, had established the Price Elasticity of Demand for residential water in different seasons using a consumer theory. Stevens et al. (1992) established the effect of price structure on residential water demand in Massachusetts for increasing block rate structure. Moreover, Olmstead et al. (2007) too established the price elasticity of demand using household consumption data for increasing block tariff structures.

Nevertheless, Thomas and Syme (1988) had adopted a contingent valuation approach in assessing the price elasticity of demand for groundwater as well as public supply of water for households in Perth, Western Australia.

Research Gaps

According to the literature review conducted, it was observed that encouraging consumers to be more mindful about consumption of pipe-borne water via a revision of tariff structure will be a feasible solution to reduce the water stress in the Colombo city. Moreover, it would help NWSDB, be more financially sustainable. However, prior to a revision of the tariff structure, identifying the price elasticity of demand and more and less responsive blocks of consumption would enable the implementation of a more effective and socially acceptable tariff revision. In assessing the price elasticity of demand time series analysis can be used, as it has proved to be successful in assessing Price Elasticity of Demand for increasing block tariff structures.

Methodology

Research Design

This study, first, attempted to establish whether the demand for pipe-borne water among domestic consumers in the Colombo city is

responsive to changes in tariff levied. Then, it attempted, depending upon its responsiveness, to identify whether there existed a disparity among the blocks of consumption with respect to price elasticity of demand, and thereby to identify which blocks of tariff were more and less responsive to changes in price. Thus, the study would be exploratory in nature (Creswell and Clark, 2011).

Sampling Design

Population

As the domestic consumer density in the Colombo city is much higher than the other parts of the country, with the expectation of adequate and uniform sampling, the population chosen for the study was the domestic consumers depending on pipe-borne water in the Colombo city, Sri Lanka.

Sampling Method

The pipe-borne water provision in the Colombo city is, first, divided into two divisions, as the Colombo City South and Colombo City North, and thereafter, further sub-divided into four area engineers' zones as Borella, Mattakkuliya, Kirulapone and Fort. From them, the Colombo City South, as the division and Fort, as the area engineers' zone were chosen for the study, as the highest residential consumer density was observed in Fort area engineers' zone. Therefore, from Fort, 200 domestic consumers were selected using simple random sampling. It was assumed that the consumer group chosen was fairly homogenous with respect to socio-economic characteristics, due to the large middle-income population living in the area.

Data Collection Process of the Study

The monthly consumption of pipe-borne water by 200 domestic consumers, attached to Fort area engineer's office, was obtained from the same, for a period of nine (09) months, before and after, the revision of tariff structure in October 2012.

In addition to them, the tariff structures for domestic consumers, before and after, the revision were obtained from NWSDB, in order to facilitate calculation of Price Elasticity of Demand for consumers of the Colombo city.

Statistical Analysis Design

The statistical measures of central tendency, mean, median and mode, and the statistical measures of dispersion, range, variance and standard deviation, were utilized for the statistical analysis. Microsoft Excel and Statistical Package for Social Sciences (SPSS) were used to facilitate analysis purposes. The detailed analysis plan is depicted in Table 1.

Table 1: Summary of Statistical Methods & Tools

Method	Tools
Descriptive Statistics	Frequency Distributions, Graphs, Measures of, Central Tendency & Dispersion
Descriptive Statistics & Economic Equations	Measures of, Central Tendency & Dispersion and Price Elasticity of Demand

Results & Discussion

Results

Consumption Patterns of the Sample

The consumption patterns of the sample, both before and after the tariff revision, were analyzed using SPSS. The results obtained from the overall analysis, prior to break down of the data set according to the blocks of consumption are depicted in Table 2.

Table 2: Statistical Analysis of Overall Consumption Patterns

Statistical Measure	Before Tariff Revision	After Tariff Revision
Mean	22.71 units	19.60 units
Median	23 units	19 units
Mode	23 units	18 units
Standard Deviation	9.4255	10.4084
Variance	88.841	108.335
Range	50 units	51 units
Minimum	2 units	0 units
Maximum	52 units	51 units

Thereafter, the consumption patterns were further analyzed decomposing them into the blocks of consumption. The results obtained are depicted in Table 3.

Table 3: Statistical Analysis of Block-wise Consumption

		Before Tariff Revision			After Tariff Revision		
Notation	**Block of Consumption**	**Frequency**	**Percentage**	**Cumulative Percentage**	**Frequency**	**Percentage**	**Cumulative Percentage**
1	00-05	3	1.5	1.5	21	10.8	10.8
2	06-10	16	8.2	9.8	17	8.8	19.6
3	11-15	28	14.4	24.2	27	13.9	33.5
4	16-20	35	18.0	42.3	41	21.1	54.6
5	21-25	49	25.3	67.5	30	15.5	70.1
6	26-30	24	12.4	79.9	25	12.9	83.0
7	31-40	30	15.5	95.4	29	14.9	97.9
8	41-50	8	4.1	99.5	3	1.5	99.5
9	51-75	1	0.5	100.0	1	0.5	100.0
10	Over 75	0	0	100.0	0	0	100.0
	Total	194	100.0	-	194	100.0	-

Determination of Change in Price

The tariff structures for domestic consumers, implemented by NWSDB, before and after the tariff revision in October 2012, were obtained. Although the tariff levied by NWSDB consists of both fixed and variable components, thus, is a two-part tariff scheme, only the variable component, the unit rate, had been changed, during the tariff revision in October 2012, while the fixed component has remained unchanged. The two tariff structures are depicted in Table 4.

Table 4: Tariff Structure Before and After the Revision

	Before Revision		After Revision	
Block of Consumption	**Usage Charge Rs. / Unit**	**Monthly Service Charge Rs.**	**Usage Charge Rs. / Unit**	**Monthly Service Charge Rs.**
00-05	3.00	50.00	12.00	50.00
06-10	7.00	65.00	16.00	65.00

11-15	15.00	70.00	20.00	70.00
16-20	30.00	80.00	40.00	80.00
21-25	50.00	100.00	58.00	100.00
26-30	75.00	200.00	88.00	200.00
31-40	90.00	400.00	105.00	400.00
41-50	105.00	650.00	120.00	650.00
51-75	110.00	1,000.00	130.00	1,000.00
Over 75	120.00	1,600.00	140.00	1,600.00

As there was no change in the monthly service charge (the fixed component), the usage charge (the variable component) will only affect the price elasticity of demand. Prior to calculation of it, the change in price as a percentage was calculated, and they are depicted in Table 5, for each block of consumption.

Table 5: Percentage Change in Price

Block of Consumption	Usage Charge - Before Revision Rs. / Unit	Usage Charge - After Revision Rs. / Unit	Percentage Change in Price
00-05	3.00	12.00	300.00%
06-10	7.00	16.00	128.57%
11-15	15.00	20.00	33.34%
16-20	30.00	40.00	33.34%
21-25	50.00	58.00	16.00%
26-30	75.00	88.00	17.34%
31-40	90.00	105.00	16.67%
41-50	105.00	120.00	14.29%
51-75	110.00	130.00	18.18%
Over 75	120.00	140.00	16.67%

Determination of Change in Consumption

From the consumption data obtained from NWSDB, for the 200 consumers attached to area engineers' office at Fort, first, the average consumption of each consumer for a period of nine (09) months before and after the tariff revision was calculated. Thereafter, in order to prevent the impact of outliers on analysis, six (06) data items were removed.

After that, the remaining 194 data items on average consumption, before and after the tariff revision, were decomposed according to the

blocks of consumption, and the percentage change in quantity was calculated.

Determination of Price Elasticity of Demand

After obtaining the percentage change in consumption, then, using the percentage change in prices, the Price Elasticity of Demand for each consumer, for each block of consumption was calculated.

Thereafter, for each block of consumption, the average Price Elasticity of Demand was calculated. In order to understand the deviation of the consumers from the mean, the standard deviation too was calculated. The results are depicted in Table 6.

Table 6: Block-wise Price Elasticity of Demand

Block of Consumption	Average Price Elasticity of Demand	Standard Deviation
00-05	-0.02	0.08
06-10	-0.08	0.26
11-15	-0.19	2.12
16-20	-0.51	1.56
21-25	-0.87	4.24
26-30	-0.87	2.32
31-40	-0.76	2.42
41-50	-0.32	1.47
51-75	-0.06	0.79
Over 75	-	-
Average PED = -0.41	Standard Deviation among PEDs = 0.3519	

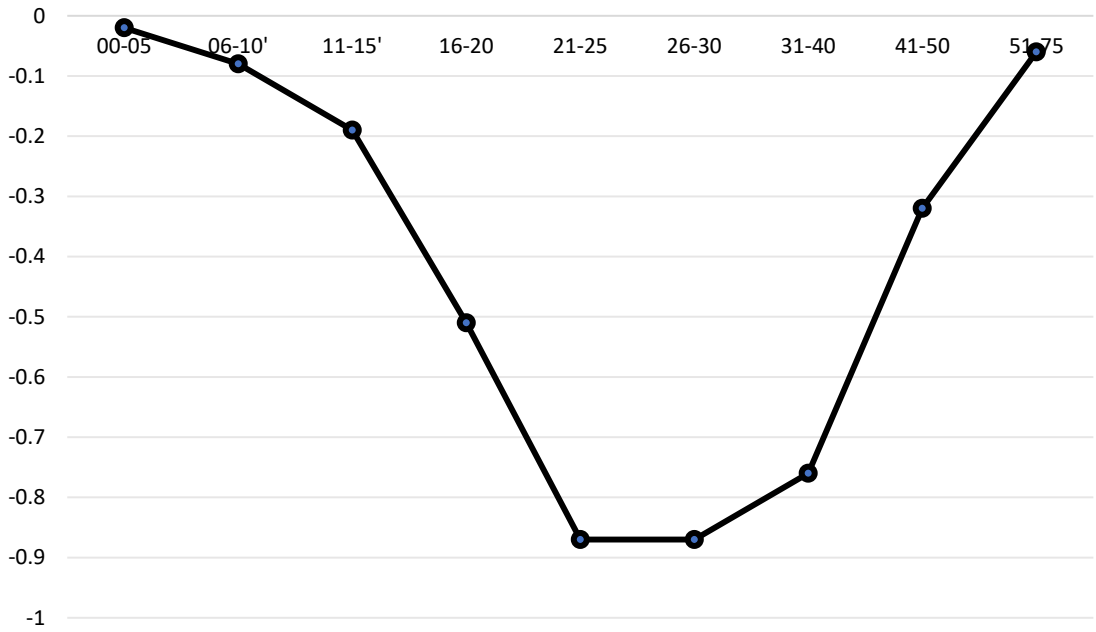

Figure 1: Block-wise Variation in Price Elasticity of Demand

Results and Discussion

Overall Consumption

According to the statistical analysis of overall consumption of the sample, Table 2, it is observed that with the revision in tariff, the mean consumption has reduced approximately by 14%. Furthermore, the mode and median consumption have reduced. These, along with the measures of dispersion calculated, such as range, imply that the consumption of pipe-borne water in the Colombo city, is sensitive and responsive to the changes in prices, and thus, a Price Elasticity of Demand can be expected.

Moreover, according to Table 3, which has analyzed the consumption patterns of the sample according to the blocks of consumption, it is observed, that after the revision more consumers are concentrated at lower blocks. For an example, the increase in percentage of consumers consuming 00-20 units is 12.3%, whereas the decrease in percentage of consumers consuming 21-50 units too is 12.5%. These two percentages being approximately equal implies the validity of the claims, that the demand for pipe-borne water is responsive to

price and that it can be used as a tool to discourage wasteful consumption.

Disparity among Blocks of Consumption

As the demand for pipe-borne water is observed to be price-elastic, then, it was checked whether there was a disparity among the blocks of consumption with respect to Price Elasticity.

According to Table 6 and Figure 1, which depict the block-wise variation in Price Elasticity of Demand, it is observed that there is a significant variation in Price Elasticity of Demand. The Price Elasticity of Demand is lower at the first three and the last two blocks, and it is significantly high for the four blocks in the middle.

Thus, it can be inferred that there is a significant variation among the blocks of consumption with respect to Price Elasticity of Demand.

More and Less Responsive Blocks of Consumption

As observed in Table 6 and Figure 1, there is a significant variation in Price Elasticity of Demand among the blocks of consumption. The average Price Elasticity of Demand for the first three blocks being lower, along with the overall average consumption calculation support the fact, that the consumers have to essentially use up to 15 units, in order to satisfy their basic needs. However, the consumption of additional units up to a maximum of 40 units can be wasteful, as those blocks have a quite high price elasticity of demand. Thereafter, even the highest consumption is responsive to price; however, the responsiveness is still less than the four blocks in the middle.

Thus, it can be inferred that the first three and the last two blocks are less responsive to changes in price, while the four blocks in the middle are more responsive to the changes in price. This reestablishes the claim that wasteful consumption can be prevented via a revision of tariff.

Conclusion

For a number of reasons, including rapid urbanization, increase in population, climatic conditions accompanied by increased pollution

and depletion of water sources, there exists a water problem in the Colombo city. This has ultimately resulted in several consequences, such as health and sanitation issues, water stress and threats to the financial sustainability of NWSDB.

Encouraging water conservation will be, thus, a pragmatic solution to reduce the magnitude of the problem. One way of achieving it and preserving economic efficiency related to the service has been identified as the revision of tariff structure. However, in an instance where an increase block tariff structure is employed by NWSDB, a uniform increase throughout the blocks would jeopardize the economic efficiency related to the service. Therefore, in the effort to implement an effective and acceptable tariff structure, assessment of Price Elasticity of Demand is an essential pre-condition to be satisfied. This study attempted to establish the Price Elasticity of Demand for the provision of water to the domestic consumers in the Colombo city.

In order to achieve the objectives of the study, the consumption patterns of 200 consumers, chosen from the Colombo city, after and before the last tariff revision in 2012, were assessed and the Price Elasticity Demand was calculated. The results showed that the consumers are responsive to the changes in price, or tariff, in the case of water, and a disparity among the different blocks of consumption with respect to Price Elasticity of Demand was observed. In the nine blocks of consumption considered, the first three blocks and the last two blocks were less responsive to changes in price, whereas the four blocks in the middle were more responsive to price. Therefore, it was observed that up to a maximum of 40 units the consumption can be wasteful and it can be prevented via a tariff revision.

This study has few implications on the policy making related to water tariff. It is that dependent on the motive of the tariff, the revision of unit rates for different blocks of consumption can be varied. If the motive is to preserve welfare of the society and economic efficiency and encourage conservation, then, the revision of unit rates for blocks of consumption, which are more responsive to price, could be made upward and higher. However, if the motive of the revision of tariff is to increase the overall revenue, then, irrespective of the blocks, for all blocks, the unit rates could be changed. Moreover, linking this

change to the inflation index would be more realistic and socially acceptable.

Moreover, NWSDB, the main authority instrumental in providing pipe-borne water to the Colombo city, can utilize these findings to estimate the responsiveness of quantity consumed to the changes in price, and thereby revise the tariff structure in a more realistic and socially acceptable way. Furthermore, the methodology could be adopted to extend the study for all the areas where NWSDB is instrumental in the provision of water, to introduce a regional tariff structure, reflective of consumer needs in different regions, rather than keeping to the currently utilized, uniform tariff structure. Moreover, even for commercial, industrial and other sectors, this assessment could be extended to efficiently provide the service, with minimal financial burden.

Furthermore, the study attempted to establish the Price Elasticity of Demand for a utility. While there were other methods, such as contingent valuation method, it could be proved that the time series analysis too is possible in this effort, following other similar studies. Thus, this knowledge of methodology can be adopted in future studies. Moreover, the study could be extended to the whole country, as and when the requirement arises to study and analyze the responsiveness of consumers to changes in tariff, not only for pipe-borne water, but also for other utilities.

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Tourist Arrivals in Sri Lanka: A Comparative Study of Holt- Winter's versus Box- Jenkin's Modeling Methods

Sebastian Reyalt Gnanapragasam[1]*

[1]Department of Mathematics, Faculty of Natural Sciences, The Open University of Sri Lanka, Nawala, Sri Lanka

Abstract

Tourism is one of the vastly growing and largest industries in the world. Contribution of tourism to Sri Lanka's total foreign exchange earnings in 2016 amounted to 14.2%. After the civil strife in Sri Lanka, tourist arrivals continue to grow annually. Therefore, the post- conflict tourist arrivals were considered for this study. Forecasting is an essential analytical tool in tourism policy and planning. In all the regions at all times, there is no specific model that outperforms other models regularly. Therefore, the objective of this study is to compare Holt-Winter's and Box- Jenkin's methods of modeling the tourist arrivals and to recommend a better method to forecast the future tourist arrivals in Sri Lanka. Appropriate tests were applied in modeling exercises for both methods. The results demonstrate that, during June 2009 to June 2017, nearly 10.5 million of tourists had visited the island. Both models are adequate for forecasting tourist arrivals. However, based on the forecasting accuracy measures of the model, the Box-Jenkin's

**Correspondence should be addressed to Mr. S. R. Gnanapragasam.*
Email: *srgna@ou.ac.lk*
https://orcid.org/0000-0003-1411-4853

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method outperforms the Holt- Winter's method. The Box- Jenkin's model gives approximately 90% forecasting accuracy and therefore it is recommended to forecast the tourist arrivals in Sri Lanka. Accordingly, around 1.15 million of tourists arrived in Sri Lanka in the second half of the year 2017, and it is about 5.7% increase compared to the same period in 2016. Further, over 235,000 tourists arrived in December 2017, which was the highest monthly arrival in the history of Sri Lanka tourism so far.

Keywords: *Box- Jenkin's, Holt- Winter's, Tourist arrivals*

Introduction

Tourism is one of the fastest growing industries in the world. It contributes to economic development of a country in terms of generating foreign exchange earnings and employment opportunities. After identifying the need to set up an institutional framework, in 1966, the government of Sri Lanka decided to develop tourism in a planned and a systematic manner. As a result, currently tourism in Sri Lanka is managed by Sri Lanka Tourism Development Authority (SLTDA). In Sri Lanka, the tourism sector continues to perform well and is able to retain its rank in the third level as one of the main sources of foreign exchange earners for the national economy. According to the Annual Statistical Report 2016 of SLTDA, the contribution of the tourism to Sri Lanka's total foreign exchange earnings in 2016 amounted to 14.2%.

Sri Lanka has always been a tourist destination due to its natural beauty and uniqueness. It has continued to attract foreign investors and tourists since its independence in 1948. Though from the beginning, tourist arrivals in the island continued to grow annually, Sri Lanka had some setbacks in this sector due to factors such as Tsunami in 2004, world economic crisis in 2009 and mainly due to uncertainty in security during the ethnic conflict from 1983 to 2009. The studies of Gnanapragasam and Cooray (2016); Gnanapragasam, Cooray and Dissanayake (2016), have shown that, there was a dramatic growth in tourist arrivals in Sri

Lanka after June 2009. Therefore, in this study, only the post-conflict series of tourist arrivals is taken for the analysis.

Forecasting is an essential analytical tool in tourism policy and planning. These decisions have to be taken by the relevant authorities in a way that facilitates the needs of the future tourists in Sri Lanka. Song and Li (2008) had done a comprehensive review of published studies from the year 2000 on tourism demand modelling. One of the important results in this review is that the methods used in analyzing and forecasting the demand for tourism had been more varied. Further, this review showed that, as far as the forecasting accuracy is concerned, there is no single model that consistently outperforms than other models in all aspects. Therefore, it recommends the application of several modeling methodologies to forecast the tourism demand, and identify the best model based on the forecasting accuracy.

Post- conflict tourism demand in Sri Lanka was forecast using different methodologies by some researchers in the past. Kurukulasooriya and Lelwala (2014) had used the classical decomposition method and it showed a forecasting accuracy of 96%. In the study of Gnanapragasam and Cooray (2016), the dynamic transfer function modeling method was tried out with 91.37% forecasting accuracy. Further, the method of state space with 94.05% forecasting accuracy was employed by another study of Gnanapragasam *et al.* (2016). Moreover, Autoregressive Integrated Moving Average (ARIMA) and decomposition modeling methods were compared in the study of Ishara and Wijekoon (2017) and they recommended that the decomposition method performed well in terms of accuracy of the fitted models.

The exponential smoothing method was applied for the modeling exercises, for forecasting tourist arrivals in different regions in some parts of the globe, in the following studies. Bermudez, Segura and Vercher (2007) argued that the additive Holt–Winters model was inappropriate if the seasonal components or the error variance depend on the level of the series, but it could also be useful after an adequate data transformation for the UK air passenger data. In the study of Witt, Newbound and Watkins (1992) showed that the

exponential smoothing generates method forecasts with lower error magnitudes than other modeling methods for Las Vegas arrivals data. In Lim and McAleer (2001) study too, the Holt–Winters additive and multiplicative seasonal models outperformed the other models in forecasting arrivals to Australia from Hong Kong, Malaysia and Singapore. Akuno, Otieno, Mwangi and Bichanga (2015) had compared two models based on the accuracy of the models and it was identified that double exponential smoothing model was better than ARIMA modelling to forecast tourist arrivals in Kenya. The common theme of those studies suggests that, generally forecasting accuracy is high in exponential smoothing modelling and this approach obtains a level of accuracy comparable to those of other more sophisticated models.

However, in some previous studies on tourism demand for different countries in the world, it is recommended that ARIMA modeling method is the most accurate method for forecasting tourist arrivals. Cho (2001) said that univariate ARIMA is a more suitable method and can be applied to forecast the fluctuating series of visitor arrivals from different countries to Hong Kong. The results of Chu (1998) showed that the accuracy of the forecasts differs depending on the country being forecast, but that the ARIMA model is the most accurate method for forecasting international tourist arrivals in Asian- Pacific countries. Loganathan, Nanthakumar and Yahaya (2010) recommended that ARIMA model with seasonal effects approaches had offered valuable insights and provided reliable forecasts of tourism demand in Malaysia. Analytic results of the study of Chang, Hsueh and Tian (2011) demonstrated that ARIMA outperformed other approaches in terms of accuracy of models and provided effective alternatives for forecasting tourism demand with evidence from Taiwan. The results of Saayman and Saayman (2010) showed that seasonal ARIMA models deliver the most accurate predictions of arrivals in South Africa and it further indicated that the methods that take into account the seasonality of international tourist arrivals outperform the others in terms of forecasting accuracy. According to the preliminary analysis of Gounopoulos, Petmezas and Santamaria (2012), the ARIMA model outperforms other exponential smoothing models as a directional forecasting tool for

tourist arrivals in Greece. The results of Chaitip, Chaiboonsri and Mukhjang (2008) confirmed that the best forecasting method based on the structural modelling methods for international visitor arrivals in Thailand that established a single variable is the seasonal ARIMA.

From these past studies it can be concluded that, in all the regions at all times, there is no specific model that outperforms other models regularly. Also, some of them recommend Holt-Winter's is the better method while the others recommend the Box- Jenkin's as the better method. Therefore, the objective of this study is to compare Holt-Winter's and Box- Jenkin's methods of modeling the tourism demand and to recommend a better method based on the accuracy of the model to forecast the future tourism demand for Sri Lanka.

For this study, monthly tourist arrivals from June 2009 to June 2017 were extracted from the Statistical Annual Reports of SLTDA. To develop the models by both methods, the series from June 2009 to December 2016 were used, whereas the arrivals from January 2017 to June 2017 were used for the validation of the fitted models.

Materials and Methods

Preliminary analysis

The following techniques were carried out to check the behavior of the series, or in other words, to check the stationary condition of the series, before developing any models as the preliminary analysis. *Eviews* and *MINITAB* software were used to get the output of the results. In this subsection, Y_t is defined as the response variable at the time t.

Inspecting the behavior of the series

The plot of time series is generally used to get an idea about the series and its behaviour. Also, it is used to inspect extreme observations, missing data, and elements of non-stationary such as trend or seasonality or cyclic pattern or irregular variations.

Testing unit root

Augmented Dickey- Fuller (ADF) test is used to test whether the series has a unit root. Also, it is used to confirm, statistically, that the stationary of the series in terms of trend availability.

Test statistic for the model $Y_t = \rho Y_{t-1} + u_t$ and $-1 < \rho < 1$, is $DF = \frac{\hat{\rho}}{SE(\hat{\rho})} \sim t_{n-1}$, where u_t is the white noise and n is the number of observations. The hypothesis to be tested here is: H_0: series has unit root $(|\rho| = 1)$ versus H_1: series has no unit root $(|\rho| < 1)$.

Testing seasonality

Kruskal- Wallis test is used to confirm, statistically, the existence of seasonal pattern in the series. The hypothesis to be tested in this test is: H_0: series has no seasanality versus H_1: series has seasonality. The test statistic (H) of Kruskal- Wallis test is defined as:

$H = \frac{12}{N(N+1)} \sum_{i=1}^{n_i} \frac{R_i^2}{n_i} - 3(N+1) \square \chi^2_{L-1}$, where N is the total number of rankings, R_i is the sum of the rankings in a specific season, n_i is the number of rankings in a specific season and L is the length of season.

Determining the nature of the process

Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) are examined to determine the nature of the process under consideration. If both ACF and PACF decay exponentially then the series is stationary.

ACF at lag k is defined by $\rho_k = \frac{\operatorname{cov}\left[\left(Y_t - \hat{Y}_t\right)\left(Y_{t+k} - \hat{Y}_{t+k}\right)\right]}{\sqrt{\operatorname{var}\left(Y_t - \hat{Y}_t\right)\operatorname{var}\left(Y_{t+k} - \hat{Y}_{t+k}\right)}}$.

If the first several autocorrelations are persistently large in the graph of ACF and trailed off to zero rather slowly, it can be

assumed that a trend exists and hence the time series is non-stationary.

PACF between Y_t and Y_{t+k} is the conditional correlation between Y_t and Y_{t+k} and defined as follows:

$$\phi_{kk} = corr\left(Y_t,\ Y_{t+k} \mid Y_{t+1},\ Y_{t+2},\ldots,Y_{t+k-1}\right).$$

Transforming to stationary series

The differencing method is employed to transform the non-stationary series into a stationary series so as to improve the forecasting performance as follows:

Regular differencing: If the series has a trend then by taking first difference (or at most 2 differences) the trend can be eliminated from the series and it is defined as $W_t = Y_t - Y_{t-L}$, where $L = 1 \text{or } 2$.

Seasonal differencing: In this method, differences are taken at seasonal lags. If the spikes appear repeatedly in the ACF graph at particular lags, then it can be assumed that there is a seasonal pattern in the series. It is defined as: $W_t = Y_t - Y_{t-L}$, where L is the length of the season.

Developing Holt-Winter's modelling method

Exponential Smoothing is a method of forecasting that induces historical patterns such as trends and seasonal patterns into the future. An exponentially weighted moving average refers to a weighted moving average of the series in which the weights decay exponentially.

Single Exponential Smoothing (SES) method is used for short-term forecasting, usually just one period into the future. The model assumes that the series fluctuates around a reasonably stable mean (no trend or consistent pattern of growth).

Double Exponential Smoothing (DES) method is used when the series shows a trend. This method with a trend works much like SES except that two components (level and trend) must be updated each period.

Holt-Winter's Seasonal Exponential Smoothing Method is used when the series shows trend and seasonality. To handle seasonality, a third parameter is added in addition to the parameters in DES. Depending on the type of seasonality, multiplicative and additive seasonal models can be developed. This method is relatively good for short-term forecasting. To apply this method, there is no need for large amounts of historical data and also it is the preferred forecasting technique by many statisticians.

The multiplicative Holt-Winter's model containing linear trend is represented as $Y_t = \left[a_t + b_t(t)\right] S_t \varepsilon_t$, whereas the additive Holt-Winter's model containing linear trend is represented as $Y_t = a_t + b_t(t) + S_t + \varepsilon_t$, where a_t, b_t and S_t are the level, slope and seasonal component smoothing constant respectively and ε_t is the error term at the time t.

Estimating smoothing constant is the most important part of an Exponential Smoothing Method. It is recommended by Gardner (1985) that, in practice, to compute forecasts the Optimum Smoothing Constants must be used. The common approach is to work with several values of smoothing constants and select the best combination which produces the minimum Sum of Squares of Errors (SSE) for the evaluation criteria used. This procedure is time consuming and thus the grid search algorithm in *STATISTICA* software is used to determine the smoothing constants.

Grid search algorithm

One common method to estimate the smoothing constants is to perform a grid search of the parameter space. Thus, *STATISTICA* provides each parameter from the minimum (from zero) to maximum (to one) by incrementing step by step. For each combination of parameter values, *STATISTICA* computes SSE. The *STATISTICA* provides the estimates of best 10 combinations of smoothing constants in the ascending order of SSE. In addition to this, the values are chosen by setting the initial values as 0.01 and incremental step value by 0.1 or 0.05 for all the cases.

Developing Box- Jenkin's modelling method

A model with combinations of *Auto-regressive (AR) terms* and *Moving Average (MA) terms* are generally called as Auto Regressive Moving Averages (ARMA) model. The formulation of an ARMA process is given as:

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \ldots + \alpha_p Y_{t-p} + \varepsilon_t - \beta_1 \varepsilon_{t-1} - \beta_2 \varepsilon_{t-2} - \ldots - \beta_q \varepsilon_{t-q},$$

where α_0 is a constant, α_i is an autoregressive parameter of order i, β_j is a moving average parameter of order j and ε_t is the error term at time t. If the series has a trend, it can often be converted to a stationary series by differencing and it is generally denoted as $\text{ARIMA}(p, d, q)$, where p and q are the order of autoregressive and moving average processes respectively and d indicates the amount of differencing.

In some cases, the series shows a repeating or cyclic behavior. These seasonal patterns can be very effectively used to further improve the forecasting performance. A seasonal ARIMA (SARIMA) model or $\text{ARIMA}(p, d, q)(P, D, Q)_S$ usually contains: regular $\text{AR}(p)$ and $\text{MA}(q)$ terms that account for the correlation at low lags. Seasonal $\text{AR}(P)$ and seasonal $\text{MA}(Q)$ terms that account for the correlation at the seasonal lags where d, D and S indicate the amount of regular differencing, seasonal differencing and seasonality respectively.

Checking model adequacy

Diagnostic tests are performed to determine the adequacy of the model. After identifying the tentative models, the following tests are applied to check whether the underlying conditions of diagnostic checking are satisfied by the fitted model. The necessary conditions of diagnostic checking are the residuals of the fitted models should be distributed normally and independently with constant variance. In this study, the following tests are employed to check those conditions:

Testing normality of residuals

Anderson Darling (AD) test is used to test, if a sample of data comes from a population with a specific distribution. Here the hypotheses to be tested are: H_0: the data follow normal distribution versus H_1: the data do not follow normal distribution. The test statistic of AD test is:

$AD = -N - \sum_{i=1}^{N} \frac{(2i-1)}{N}\left[\ln F(Y_i) + \ln(1 - F(Y_{N+1-i}))\right]$, where F is the cumulative distribution function of the specified distribution, Y_i are the ordered data and N is the total number of observations. In addition to the AD test, the normal probability plot is also obtained to check the normality condition of the residuals. If the plot looks fairly straight, or in other words if it is almost linear, then it can be assumed that the residuals are normally distributed.

Testing independency of residuals

One of the most important tests for detecting serial correlation is *Durbin Watson (DW)* statistic. DW statistic is used to test for randomness of residuals. The test statistic is defined as: $d = \frac{\sum_{t=2}^{n}\left(\hat{u}_t - \hat{u}_{t-1}\right)^2}{\sum_{t=1}^{n}\hat{u}_t^2}$, where $\hat{u}_t$ is the white noise of a fitted model. The DW closer to 2 reveals that the residuals are free from serial correlation. Further to DW statistic, the plot of standard residuals versus fitted values is also obtained to check the independency of residuals. If this plot shows random pattern and it almost lies within ± 2 limits, then it can be claimed that the residual is distributed independently.

Testing heteroscedasticity of residuals

White's general test is used in order to check the constant variance of residuals. Accordingly, the null hypothesis is: H_0: Homoscedasticity against the alternative hypothesis H_1: Heteroscedasticity. The test statistic of the White's general test is: $W = nR^2 \square \chi^2_{df}$, where df is the number of regressors in the auxiliary regression, R^2 is the coefficient of determination and n is

the number of observations of the dependent variable. The plot of standard residuals versus order of the observations is also obtained to check the constant variance of residuals, in addition to the White's general test. Suppose this plot looks symmetric about zero without any systematic patter and it almost lies within ± 2 limits, then it can be stated that the residuals have constant variance.

Selecting best model

In some situations, two or more models could satisfy all the conditions of the diagnostic checking. In such situations, to select the best model among those significant models, the following criterions are applied:

Akaike Information Criterion (AIC) is often used for model selection. For sample size n, the expression of AIC is given by: $\text{AIC}(k) = n\ln\left(\hat{\sigma}^2\right) + 2k$, where k is the number of parameters in the model and $\hat{\sigma}^2$ is the sample variance of the residuals.

Schwartz's Bayesian Criterion (SBC) is another widely used technique for model selection. For sample size n, the expression of SBC is given as: $\text{SBC}(k) = n\ln\left(\hat{\sigma}^2\right) + k\ln(n)$, where k is the number of parameters in the model and $\hat{\sigma}^2$ is the sample variance of the residuals. Generally, the best model is the one which gives the lowest AIC and SBC values.

Forecasting accuracy of the model

To check the forecasting accuracy of the fitted model, the *Mean Absolute Percentage Error (MAPE)* is employed. It is generally used for the evaluation of the forecast against the validation sample. To compare the average forecast accuracy of different models, MAPE statistic is used and it is defined as follows:

$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right| \times 100$, where Y_t and $\hat{Y}_t$ are the observed and predicted values at the time t respectively.

According to Lewis (1982), the forecasting accuracy of the fitted model is high when MAPE value is less than 10%. However, if the value of MAPE is in between 10% and 20%, then it is a good forecasting.

Results and Discussion

Behavior of the series

It is well known that stationary series are necessary to fit Box-Jenkin's and Holt- Winter's models for better forecasting performance. Therefore, the stationary condition of the original series of the tourist arrivals, after the civil conflict, to Sri Lanka is tested in this subsection before fitting any models. For this purpose, the entire series from June 2009 to June 2017 is used.

The Figure 1 represents the time series plot of tourist arrivals after the civil conflict in Sri Lanka.

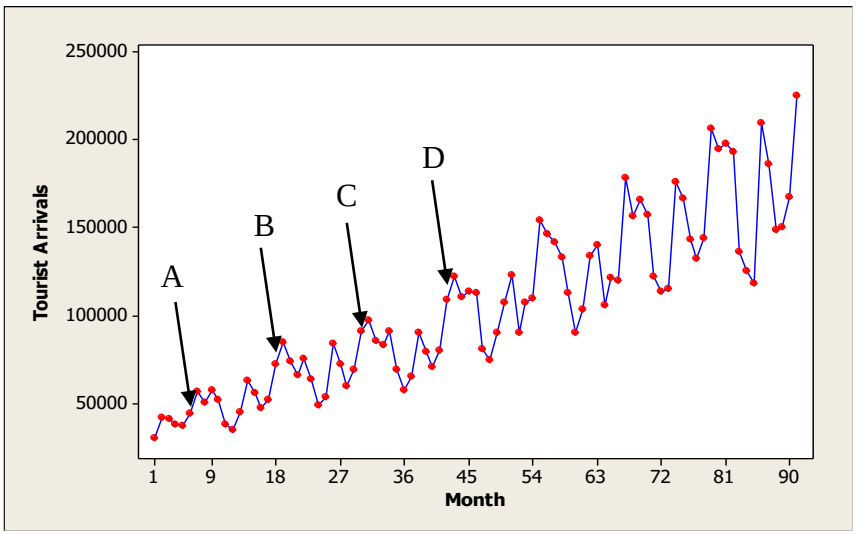

Figure 1: Time series plot of tourist's arrivals

It is noted from the plot of the time series of tourist arrivals in Figure 1 that there are no any extreme observations. Also, this plot clearly shows an upward trend. Further, it can be observed that, after every 12th point, there is a peak point, marked as A, B, C and D in Figure 1 (it repeats after every 12th month). It is a clear indication of the existence of seasonality in the original series. Since there is a trend and a seasonal pattern in the plot in Figure 1, the original series is non-stationary and therefore it has to be converted to a stationary series. For this purpose, differencing method is employed.

The first regular difference of the original series is taken and the plot of the 1st regular differenced series is shown in Figure 2.

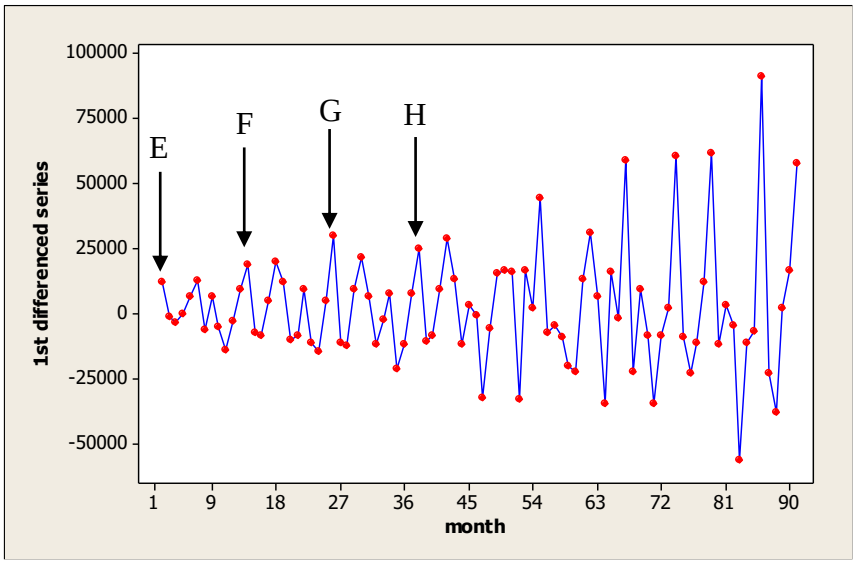

Figure 2: Plot of 1st regular differenced series

It seems from Figure 2 that there is no trend in the 1st regular differenced series. It is confirmed through the statistical test in Table 1 as well. It is further observed from Figure 2 that, after every 12th point, there is a peak point, marked as E, F, G and H in Figure 2 (it repeats after every 12th month). It further suggests that there is a seasonal pattern in the 1st regular differenced series.

Therefore, the 12th seasonal difference is taken from the 1st regular differenced series and the plot of the 12th seasonal differenced is plotted in Figure 3.

There is no clear indication of a trend or a seasonal pattern in Figure 3. It can be assumed that the 12th seasonal differenced series is stationary and it is statistically confirmed in Table 1.

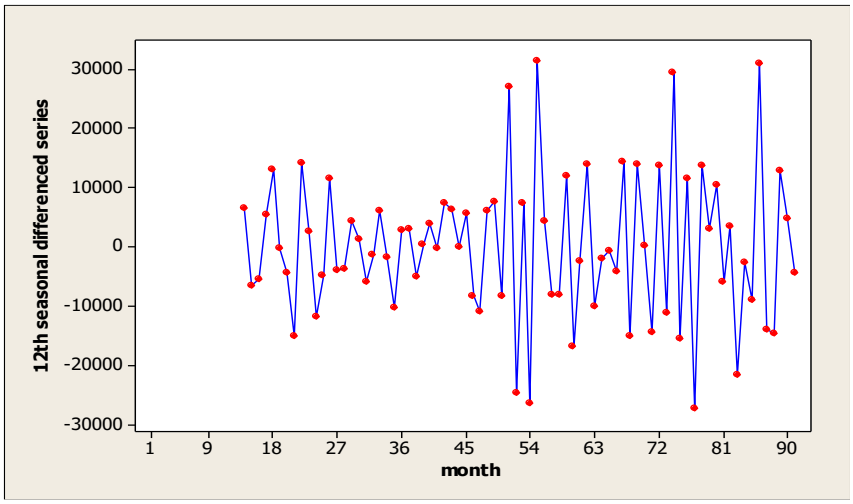

Figure 3: Plot of 12th seasonal differenced series

Figure 4 shows the plot of the autocorrelation function of the series obtained after the first regular difference. Particularly, this regular differencing is taken to remove the trend in the original series.

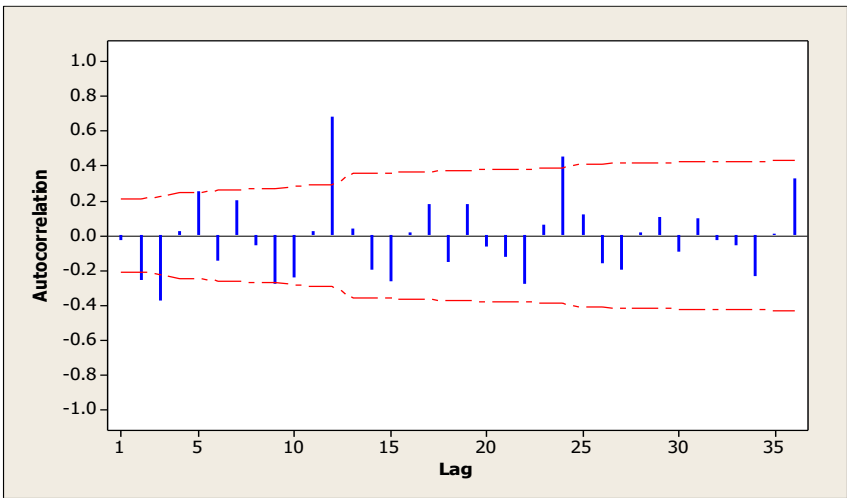

Figure 4: ACF for 1st regular differenced series

The ACF of the 1st regular differenced series shown in Figure 4 is not decaying exponentially and there are some high spikes that repeatedly appear in the middle. Therefore, it can be concluded that the 1st differenced series is also a non-stationary series. It can be further confirmed from the p-values of ADF (0.00) and Kruskal-Wallis (0.00) tests in Table 1 that the 1st regular differenced series is also non-stationary.

The Table 1 summaries the p-values of ADF and Kruskal- Wallis tests for the 1st regular difference and the 12th seasonal differenced series and the decision on the stationary condition based on those p-values.

Table 1: Summary of stationary conditions of the series

Behavior	**Test**	**p-values (*decision*) for the series**	
		1st regular differenced	**12th seasonal differenced**
Trend	Augmented Dickey-Fuller (ADF)	0.00 (*No trend*)	0.00 (*No trend*)
Seasonality	Kruskal- Wallis	0.00 (*Seasonality Exists*)	0.53 (*No seasonality*)
Decision on stationary condition		Non- stationary	Stationary

Moreover, at 12th, 24th and 36th lags high spikes can be seen in the ACF of the 1st regular differenced series in Figure 4. This seasonal pattern suggests that, this series has seasonality with length 12. Therefore, to remove this seasonality, again a 12th seasonal difference is taken and the relevant ACF plot is shown in Figure 5.

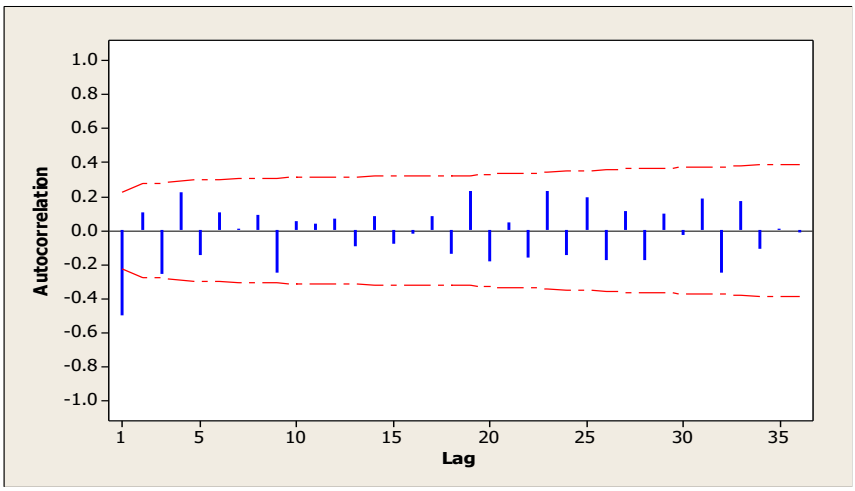

Figure 5: ACF for 12th seasonal differenced series

It can be seen from the ACF for 12th seasonal differenced series in Figure 5 that in almost all the lags, except one at the beginning spikes, are not significant. It seems this transferred series is stationary. Nevertheless, graph of PACF is also obtained for the 12th seasonal differenced series and it is shown in Figure 6.

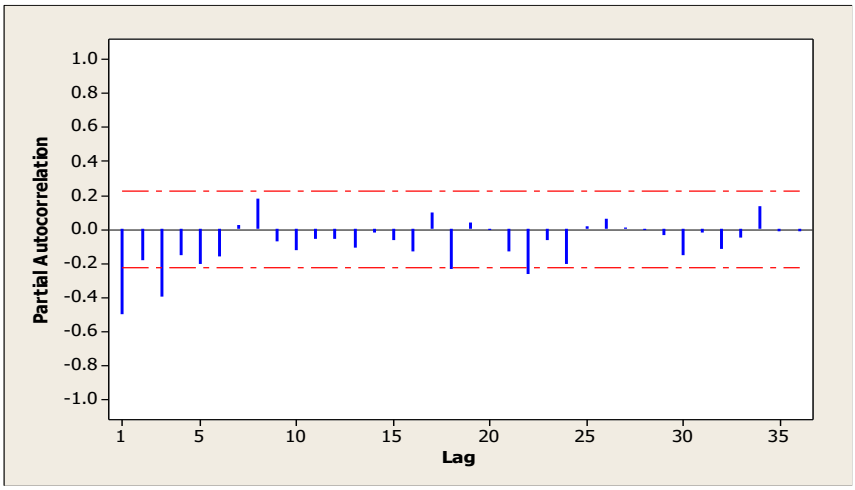

Figure 6: PACF for 12th seasonal differenced series

Now from ACF plot in Figure 5 and PACF plot in Figure 6, it can be claimed that, 12th seasonal differenced series is stationary. At the same time, the p-values of ADF (0.00) and Kruskal- Wallis (0.53) tests in Table 1 strongly confirm that, the newly generated series

by taking the 12th seasonal difference is stationary. Thus, this converted series now can be used to fit both Holt- Winter's and Box- Jenkin's models.

Developing the Holt-Winter's model

Grid search algorithm in *STATISTICA* is used to estimate relevant smoothing constants. In this algorithm the values are chosen by setting the initial values as 0.01 and incremental step value by 0.1 and 0.05. Both additive and multiplicative seasonal model types are considered in the Holt- Winter's method. The 1st choice among the best 10 combinations of smoothing constants based on the ascending order of sum of squares of errors in both model types are taken. Hence the smoothing constants corresponding to both model types with MAPE values are summarized in Table 2 as follows:

Table2: Estimates of smoothing constants of the Holt-Winter's models

Model Type	**Estimates of smoothing constants**	**MAPE**
Additive	$\alpha = 0.15,\ \beta = 0.10,\ \gamma = 0.10$	13.61
Multiplicative	$\alpha = 0.25,\ \beta = 0.05,\ \gamma = 0.05$	18.27

As far as the MAPE values are concerned, the additive seasonal model of the Holt- Winter's method is selected as the best model in this case. Therefore, the smoothing constants $\alpha = 0.15$, $\beta = 0.10$, and $\gamma = 0.10$ are obtained and the diagnostic checking to test the adequacy of the fitted Holt-Winter's additive model is carried out as follows:

Normality testing of the fitted Holt-Winter's model

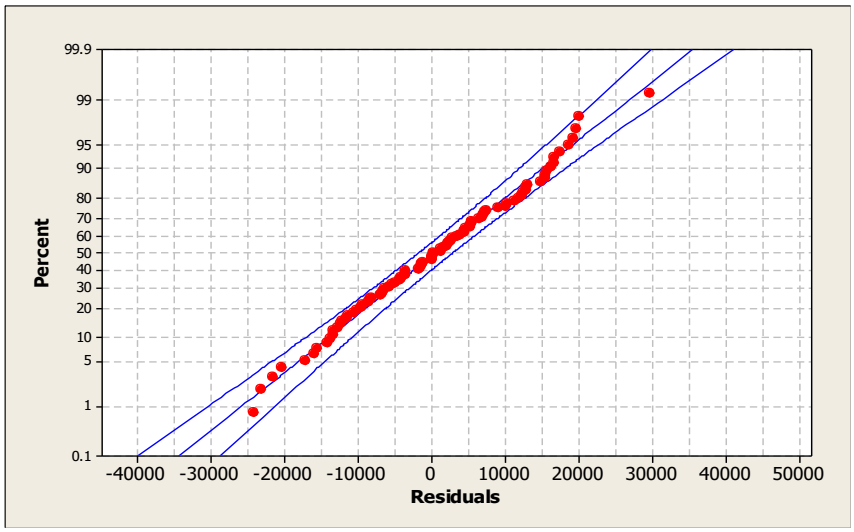

Figure 7: Normal probability plot of residuals of the Holt-Winter's model

It is noted from Figure 7 that the normal probability plot is fairly straight and therefore it can be claimed that the residuals of the Holt-Winter's model are normally distributed. Further the p-value (0.793) of Anderson Darling test very strongly confirms the result that the distribution of the residuals is normally distributed. Therefore, the first condition of the diagnostic checking is satisfied by this Holt-Winter's model.

Independency testing of the fitted Holt-Winter's model

The points in the plot of standard residuals versus fitted values in Figure 8 are scattered randomly and it almost lies within ± 2 limits. Hence it can be stated that, the residuals of the Holt-Winter's model are independent. Therefore, the second underlying assumption of the significant model is also satisfied as there is no serial correlation among the residuals of this Holt- Winter's model.

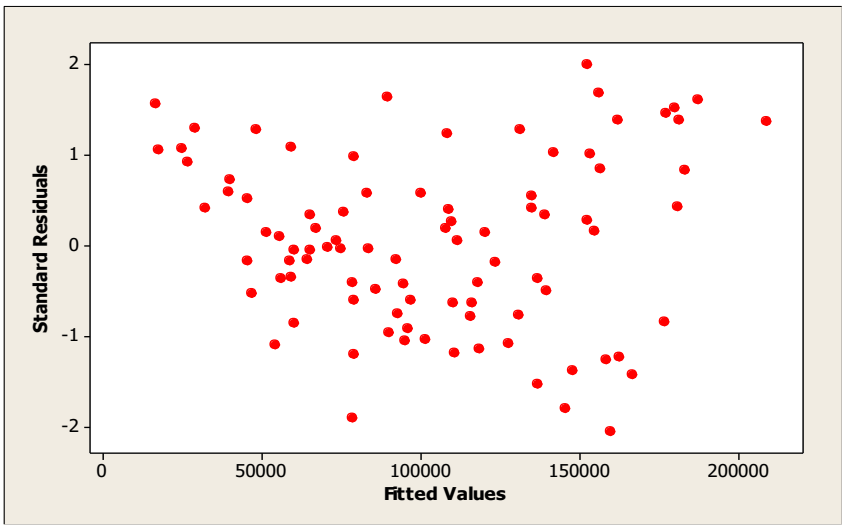

Figure 8: Plot of Standard Residuals vs Fitted Values of the Holt-Winter's model

Heteroscedasticity testing of the fitted Holt-Winter's model

Since the plot of standard residuals versus observations order of Holt- Winter's model in Figure 9 is almost symmetric about zero and within ± 2 limits, and as there is no any systematic patter, it can be confirmed that the variance of the residuals is constant. Hence, the third condition of a significant model is also satisfied. Therefore, there is no heteroscedasticity in the residuals of the fitted Holt- Winter's model.

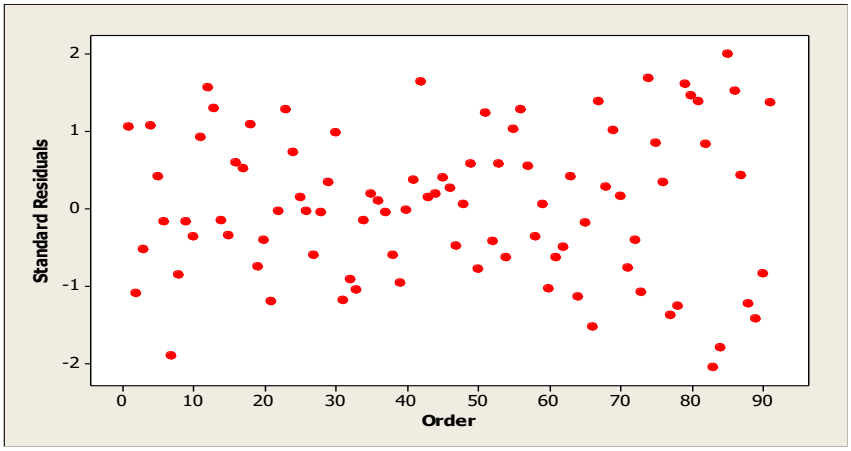

Figure 9: Plot of Standard Residuals vs Observations Order of the Holt- Winter's model

The residuals are independent and normally distributed without the heteroscedasticity. It suggests that, the model satisfies the requirements of the diagnostic checking. Therefore, it can be concluded that, the Holt- Winter's additive seasonal exponential smoothing model with smoothing constants $\alpha = 0.15$, $\beta = 0.10$, and $\gamma = 0.10$ is significant. Thus, this model can be used for the purpose of forecasting the future tourist arrivals in Sri Lanka.

Developing the Box-Jenkin's model

To develop the Box-Jenkin's model, again the same series from June 2009 to December 2016 are taken into account. From ACF graph in Figure 5 and PACF graph in Figure 6, it can be observed that, the appropriate models can have 3 AR terms and 1 MA term as the significant spikes appear at the relevant lags in those graphs. Possible different models, with all the combinations of those terms, are tried out. The selection criterions of the significant models are summarized in Table 3.

Table 3: Selection criterions of significant models

Model	**AIC**	**SBC**
SARIMA(0, 1, 1)(0, 1, 0)$_{12}$	21.06	21.09
SARIMA(1, 1, 0)(0, 1, 0)$_{12}$	21.25	21.28
SARIMA(1, 1, 1)(0, 1, 0)$_{12}$	21.19	21.29

Among three significant models in Table 3 which satisfy diagnostic checking, seasonal *ARIMA(0, 1, 1)(0, 1, 0)*$_{12}$ model is selected as the best model which has the lowest AIC (21.06) and SBC (21.09) values. The results of the diagnostic checking only of the best model are described as follows:

Normality testing of the fitted Box-Jenkin's model

The normal probability plot of the residuals of the Box-Jenkin's model in Figure 10 is almost linear and therefore it can be stated that the residuals of the model is normally distributed. Further, the p-value (0.548) of Anderson Darling test confirms that the distribution of the residuals is normal. Therefore, it can be concluded with 95% confident that the residuals of the Box-

Jenkin's model are normally distributed and it satisfies the first condition of the diagnostic checking.

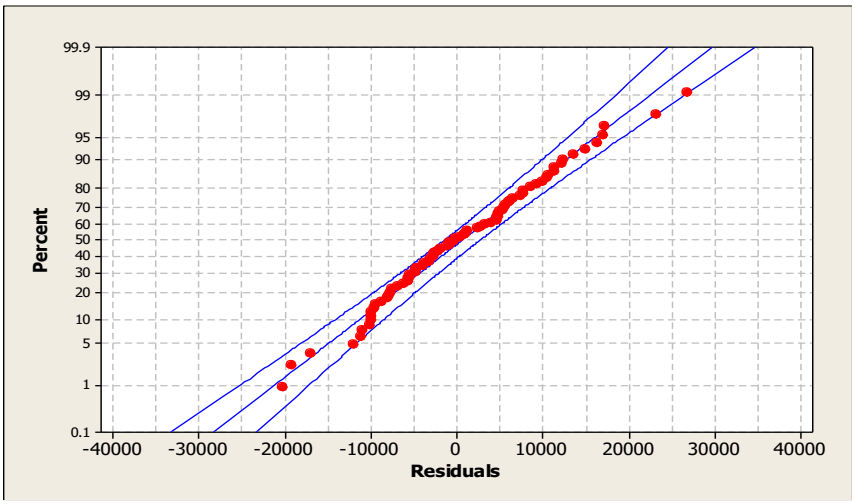

Figure 10: Normal probability plot of residuals of the Box- Jenkin's model

Independency testing of the fitted Box-Jenkin's model

It can be seen from Figure 11 that, the plot of standard residuals versus fitted values of the Box- Jenkin's model is scatted randomly and it almost lies within ± 2 limits. Therefore, the residuals are independent. Moreover, the Durbin Watson statistic (1.99) confirms that the residuals have no serial correlation. Therefore, the residuals satisfy the second condition of diagnostic checking that there is no serial correlation among the residuals of the Box-Jenkin's model.

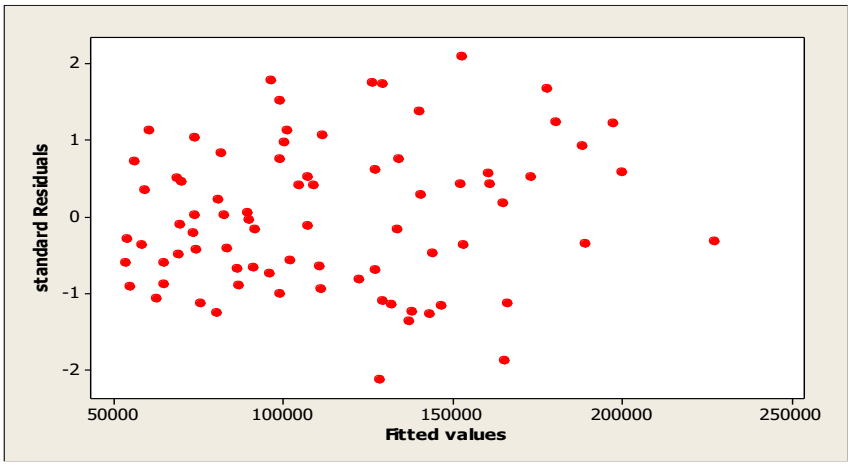

Figure 11: Plot of Standard Residuals vs Fitted Values of the Box Jenkin's model

Heteroscedasticity testing of the fitted Box-Jenkin's model

There is no any systematic patter in the plot of standard residuals versus observations order of the Box-Jenkin's model in Figure 12; it is symmetric about zero and it almost lies within ± 2 limits. Therefore, it can be claimed that the residuals of the model have constant variance. At the same time, the p- value (0.67) of White's general test strongly confirms that there is no heteroscedasticity. Therefore, it can be concluded with 95% confidence that, the variance of residuals is constant and thus no heteroscedasticity exists.

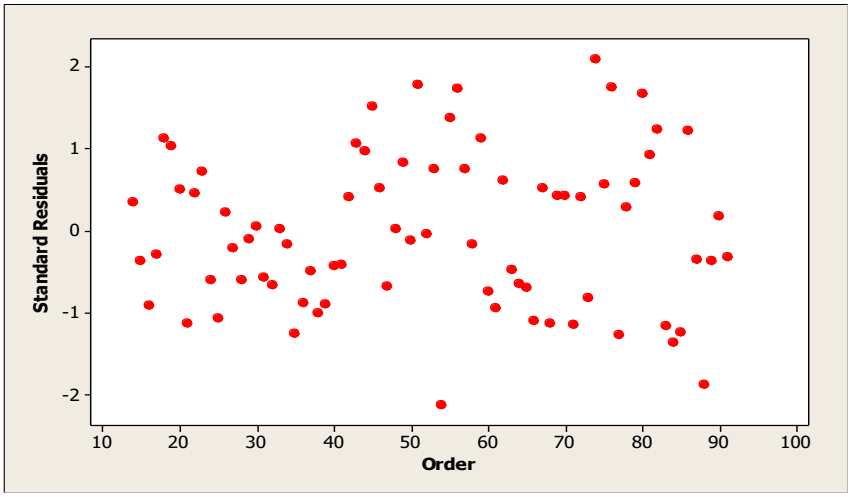

Figure 12: Plot of Standard Residuals Vs Observation Order of the Box-Jenkin's model

All three underline assumptions of the diagnostic checking are satisfied by the fitted Box-Jenkin's model. Therefore, this model is significant and it can be used for the purpose of forecasting future tourism demand for Sri Lanka.

Validating the fitted models

To check the model validation as the accuracy of the fitted model, the series from January 2017 to June 2017 are taken into account. Predicted values from both Holt-Winter's and Box-Jenkin's models are, separately, obtained in this particular period and which are summarized in Table 4 as follows:

Table 4: Observed and predicted tourist arrivals in Sri Lanka

Month in 2017	Observed Arrivals	Predicted Arrivals			
		Holt- Winter's Model	Error %	Box- Jenkin's Model	Error %
January	219,360	197,537	9.95	215,033	1.97
February	197,517	198,439	0.47	218,450	10.60
March	188,076	196,252	4.35	213,594	13.57
April	160,249	167,743	4.68	157,120	1.95
May	121,891	156,555	28.44	145,797	19.61
June	123,351	165,012	33.77	138,791	12.52
MAPE		**13.61**		**10.04**	

As far as the accuracy of the model is concerned based on the MAPE values in Table 4, both are good models. On the one hand, MAPE value of the Box- Jenkin's model is approximately 10% and therefore the accuracy of that model is very high. On the other hand, the MAPE value of the Holt- Winter's model is approximately 14% and its accuracy also good. However, when compared with MAPE values, the Box- Jenkin's method performed better than the Holt- Winter's method in terms of forecasting accuracy of the model. Therefore, the Box- Jenkin's model is recommended to forecast future tourism demand for Sri Lanka.

Forecasting future tourist arrivals in Sri Lanka

The Figure 13 represents the monthly-wise forecast of tourism demand by the method of the Box- Jenkin's from July 2017 to December 2017.

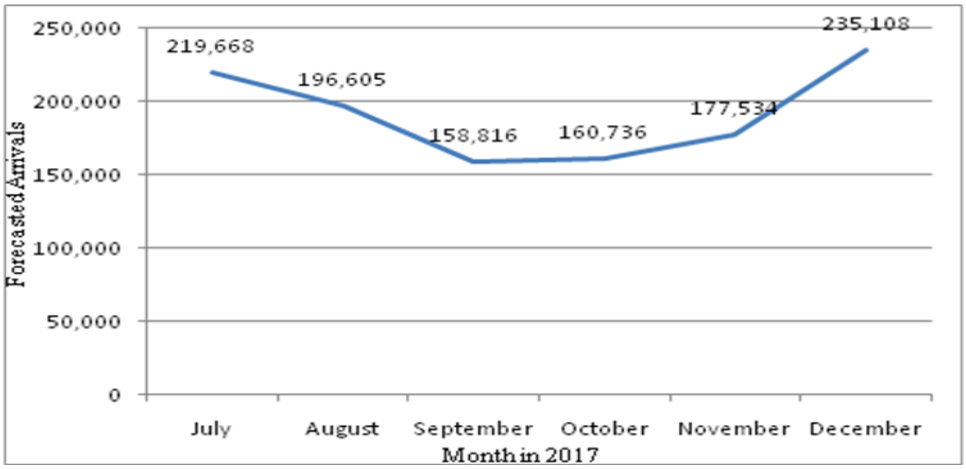

Figure 13: Monthly-wise forecast of tourist arrivals by the Box Jenkin's model

According to the month-wise forecast of tourism demand by the method of Box- Jenkin's model in Figure 13, in the month of December 2017 more than 235,000 tourists will arrive to Sri Lanka and which will be not only the highest monthly arrival for that year, but also the highest monthly arrivals in the history of Sri Lankan tourism so far. In the meantime, a lower number of tourists will come in the months of September and October in the year 2017. On the average, nearly 192,000 tourist arrivals per month are estimated for the second-half of the year 2017. Nearly 1.15 million of tourists will arrive in the second-half of the year 2017, which is 5.7% increase compared to the arrivals in the second-half of the year 2016.

Conclusions and Recommendations

Based on the series of tourist arrivals from June 2009 to June 2017, nearly 10.5 million of tourists had visited the island after the civil conflict in Sri Lanka. Accordingly, on the average, nearly 108,000 visitors per month had come to Sri Lanka as tourists.

Both models fitted by the methods of Holt- Winter's and Box-Jenkin's are significant. However, based on the forecasting accuracy of the model, it is concluded that the Box-Jenkin's method outperforms the Holt- Winter's method for tourist arrivals in Sri Lanka, after the civil conflict. Therefore, *SARIMA (0, 1, 1) (0, 1, 0)*$_{12}$ is recommended as the best model to forecast the future tourism demand for Sri Lanka.

It can also be concluded that, in the second half of the year 2017, nearly 1.15 million of tourists will arrive to Sri Lanka and it is about 5.7% increase compared to the arrivals in the second half of the year 2016. Therefore, the country must be ready to cater to them in a professional manner such as facilitating their accommodations at their required level—that will increase the demand for tourist in the future. Hence, the tourism industry could contribute significantly to the country's economy in terms of foreign exchange.

It is hereby recommended that further studies should be conducted employing the *neural network* modeling method for the post conflict tourism demand for Sri Lanka and compare the forecasting accuracy of that model with the other models fitted so far in the same time scenario.

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Estimation of Radioactivity and Associated Radiological Hazards of Cement Used in Sri Lanka

Deepa Ranjanie Abeydeera[1]*, Rohini Hewamanna[2], Mahendra Prinath Dias[3], Palee Mahawatta[4]

[1]Department of Physics, The Open University, Nawala, Sri Lanka
[2,4]Department of Nuclear Science, University of Colombo, Colombo 3, Sri Lanka
[3]Department of Electrical Engineering, University of Moratuwa, Moratuwa, Sri Lanka

Abstract

Cement used in construction work can cause internal and external radiation exposure due to the presence of natural radionuclides ^{226}Ra, ^{232}Th and ^{40}K. The radiation exposure risk can be estimated by finding the indoor absorbed dose rate and the annual effective dose. If the annual effective dose is within the internationally accepted value, use of cement can be considered safe and the risk will be within acceptable levels. The specific activities of ^{226}Ra, ^{232}Th and ^{40}K in 85 samples from eleven types of cement were measured using gamma spectroscopy with a HPGe detector and the annual effective dose was calculated to determine the radiological hazard from the natural radioactivity in the samples. The average specific activities measured in Bq kg^{-1} ranged from 21.4 ± 0.9 to 66.8 ± 1.2 ;13.8 ± 0.9 to 62.1 ± 2.3 and 83.7 ± 4.9 to 239.9 ± 5.7 for ^{226}Ra, ^{232}Th and ^{40}K respectively.

**Correspondence should be addressed to Ms. D. R. Abeydeera.*
Email: *drabe@ou.ac.lk*
https://orcid.org/0000-0002-0753-3913

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The highest activity of both ^{226}Ra and ^{232}Th were obtained in CEM III- PPC 1 cement which contains 25 % fly ash from a coal power plant. The lowest activities of ^{226}Ra, ^{40}K and ^{232}Th were observed in CEM-X imported OPC 3 cement. It was observed that for all the studied cement samples the annual effective dose ranged from 0.15 to 0.51 mSv y^{-1}.and less than the recommended maximum permissible public dose 1.0 mSv y^{-1}. The results obtained in this study indicate that there is no radiological hazard arising from the use of the studied cement varieties in building construction.

Keywords: building construction, cement, equivalent dose, radiological hazard, radionuclides,

Introduction:

All building materials, such as bricks, sand and cement derived from rocks and soil contain naturally occurring radionuclides of uranium (^{238}U) and thorium (^{232}Th) series and the radioactive isotope of potassium (^{40}K). These radionuclides are also present in raw materials used in making cement, such as limestone, gypsum and fly ash. Radium (^{226}Ra) which is a member of the ^{238}U decay series is the most important isotope radiologically since radium and its daughter products produce 98.5% of the radiological effects of the uranium series. Therefore, the contribution from ^{238}U can be considered as that of ^{226}Ra and its daughter products. The radiation exposure from building materials due to these radionuclides is due to both internal and external exposures. The external exposure is caused by direct gamma radiation from an external source. The internal exposure is caused by the inhalation of the gaseous daughter products radon (^{222}Rn) and thoron (^{220}Rn) and their short-lived secondary decay products. Cement is used as a construction material for houses and other buildings in Sri Lanka. It is also used to make cement blocks and concrete as well as for plastering walls of houses and buildings. The demand for cement in Sri Lanka is increasing as a result of the increasing population and the expansion of infrastructure. Fly ash from coal power plants is used as a raw material in the manufacture of some brands of cement.

The aim of this study was to determine the specific activities of ^{226}Ra, ^{232}Th and ^{40}K in different brands of cement and in the raw materials used to manufacture cement and to assess the associated

radiological hazard from the use of cement. Cement samples were analyzed using high-resolution gamma spectrometry.

The potential radiological hazard was determined by computing the annual effective dose. The specific activities of ^{226}Ra, ^{232}Th and ^{40}K in Sri Lankan made cement were compared with the corresponding value of cement manufactured in some other countries.

The specific activities of ^{226}Ra,^{232}Th and ^{40}K were also measured for raw materials of cement such as fly ash, gypsum, limestone, dolomite and clinker.

Materials & Methods

Sampling and sample preparation

A total of 85 cement samples manufactured in 2013 and 2014, from 11 main brands used in Sri Lanka were collected from the local market and from a cement factory. The types of cement and the proportions of raw materials in cement products are shown in Table 1.

Table 1: Brands of cement samples and the proportions of raw materials

Type of cement	No. of Samp-les	Clinker (%)	Lime-stone (%)	Fly ash (%)	Minor constituents (%)
CEM-I-OPC 1	10	95-100	-	-	0-5(Gypsum/Dolomite)
CEM-II-PLC	10	80-94	6-20	1	0-5(Gypsum/Dolomite)
CEM-III-PPC 1	10	70	-	25	5 (Gypsum)
CEM-IV-OPC 2	5	91	-	5	4 (Gypsum)
CEM-V-OPC 3	5	94	-	2	4 (Gypsum)
CEM-VI-PPC 2	20	75	-	20	5 (Gypsum)
CEM-VII-OPC 4	5	95-100	-	-	0-5(Gypsum/Dolomit
CEM-VIII Imported OPC 1	5	95-100	-	-	0-5(Gypsum/Dolomite)

CEM-IX Imported OPC 2	5	95-100	-	-	0-5(Gypsum/Dolomite)
CEM-X Imported OPC 3	5	95-100	-	-	0-5(Gypsum/Dolomite)
CEM-XI Imported PPC 1	5	65-89	-	11-35	0-5(Gypsum/Dolomite)

(OPC-Ordinary Portland Cement, PLC-Portland Limestone Cement, PPC-Portland Pozzolana Cement)

Thirty samples of raw materials were also collected from a cement factory. (Five samples each of limestone, dolomite, clinker, gypsum and 10 samples of fly ash).

The cement samples were dried in a temperature-controlled furnace for 14 hours at 110 ^{0}C to remove moisture. These samples were not sieved as the particles were very fine.

Some raw materials, such as clinker, dolomite and limestone were initially broken into small parts by using a hammer, milled using a grinder and sieved by a sieve of mesh size 250 μm. Fly ash samples were not sieved as they were already in powdered form. Gypsum samples were also sieved using a 250 μm mesh size without grinding. All raw material samples were oven dried at 110 ^{0}C for 14-21 hours to remove moisture.

Dried homogeneous samples of cement and raw materials of cement were thereafter sealed tightly in plastic containers (diameter 8.0 cm and height 2.5 cm) and kept for 30 days until radioactive equilibrium was reached.

Measurement of specific radioactivity

The specific activities of the radionuclides were determined by high resolution gamma spectrometry using a HPGe (Hyper Pure Germanium) detector with a relative efficiency of 20.6% and an energy resolution of 1.85 keV FWHM (full width at half-maximum) for the 1332 keV gamma ray line of ^{60}Co. GENIE 2000 software was used to analyze the spectra. The high resolution HPGe gamma spectrometry system consists of a p-type intrinsic Germanium co-

axial detector (type: EG and ORTEC model GEM 13200) mounted vertically and coupled to a multi-channel analyser. (Canberra S100 MCA, with 4023 channels).The detector was mounted in a cylindrical lead shield with a thickness of 10 cm to reduce the effect of background radiation.

The spectrometer was calibrated for energy and efficiency over the photon energy range of 186 keV - 2700 keV using IAEA reference materials, RGU-1 (U-ore), RGTh-1 (Th-ore) and RGk-1 (K_2SO_4), packed in containers whose geometry was identical to that of the geometry of cement and raw material samples. The accumulation time for gamma ray spectra ranged between 61,200 and 64,800 seconds, sufficient for a statistical error of less than 1%. Background measurements were also taken over the same period of time. For all samples, the ^{226}Ra specific activity was measured from the gamma ray line of 351.9 keV (37.1%) from ^{214}Pb and 609.3 (46.1%), 1120.2 (15.1%) and 1764.5 (15.9%) keV lines from ^{214}Bi. The specific activity of ^{232}Th was determined from 583.1 (86%) and 2614 keV gamma lines of ^{208}Tl, 238.6 (43.6%) keV line from ^{212}Pb and 338.4 (12%) and 911.1 (29%) keV lines from ^{228}Ac. The ^{40}K concentration was calculated from its 1460.8 keV gamma line. The values inside the parentheses are the absolute probabilities of the gamma decay.

Estimation of specific activity

The activities of radionuclides in the samples were computed using equation (1). The specific activities in Bq kg^{-1} of the radionuclides were calculated by dividing the activity by the mass of the dried samples expressed in kilogram using equation (2).

The activity A and specific activity A_{sp} are given by,

$$A = \frac{Z}{r\epsilon\, t} \qquad (1)$$

$$A_{sp} = \frac{A}{M} = \frac{Z}{Mr\epsilon\, t} \qquad (2)$$

Where, Z is the background subtracted counts under the photopeak, r - the gamma emission probability, t -the counting time of samples and ϵ the photopeak efficiency for the corresponding gamma energy and M the dry mass of the sample.

The photopeak efficiency ϵ was calculated using equation (3),

$$\epsilon = \frac{Z'}{rA_{st}t'} \quad (3)$$

Where, A_{st} - Activity of the IAEA reference material (RGU), t'- counting time of the reference material, r - gamma emission probability, Z'- the background subtracted count under the photopeak for the reference material.

Estimation of Uncertainty of Specific Activity

The uncertainty of the specific activity depends on the uncertainty of the measured parameters, namely the count-rate, the efficiency of the detector and the mass of the sample.

$$A_{sp} = \frac{Z}{Mr\epsilon t} = \frac{C}{Mr\epsilon} \quad (4)$$

Where, $c = \frac{Z}{t}$ is the count-rate.

It can be shown that the most probable error of the specific activities can be expressed by the equation 5 (Topping, 1972).

$$(\delta A_{sp})^2 = A_{sp}{}^2 \left\{ \left(\frac{\delta C}{C}\right)^2 + \left(\frac{\delta \epsilon}{\epsilon}\right)^2 + \left(\frac{\delta r}{r}\right)^2 + \left(\frac{\delta M}{M}\right)^2 \right\} \quad (5)$$

Where, δA_{sp} - The uncertainty of the specific activity, δc - The uncertainty of the count-rate, δr - The uncertainty of gamma emission probability, $\delta\epsilon$ – The uncertainty of the efficiency, δM - The uncertainty of the measurement of mass.

Estimation of Minimum Detectable Activity (MDA)

The MDA is a measure of the lowest level at which sample activity can be distinguished from the background. The minimum detectable activity (MDA) of the gamma spectroscopic system was calculated using the equation (6) (Curie,1968).

$$\text{MDA} = \frac{k\alpha\sigma}{\epsilon r t M} (\text{Bq kg}^{-1}) \quad (6)$$

Where, σ – The standard deviation of the background in the region of interest which is the square root of the number of counts of the

spectrum in a given time, since it has a Poisson distribution, and $k\alpha$ –The statistical coverage factors equal to 1.645 at 95% confidence level.

Assessment of the radiation hazard

In this study, the indoor annual effective dose was determined to assess the potential radiation hazard.

The Annual Effective Dose Rate (A.E.D.)

The indoor annual effective dose due to the gamma ray emission from the radionuclides ^{226}Ra, ^{232}Th and ^{40}K in cement used as a building material to construct a reference room with dimensions 6 m x 4 m x 3 m can be calculated from the Equation 7 given below (Interim report, The Netherlands, 1985). It is assumed that the ceiling, walls and the floor of the room are made of concrete with density 2400 kg m^{-3} and thickness 12 cm.

$$\text{A.E.D.} = DtTF \qquad (7)$$

Where, D - Absorbed dose rate in air mGy h^{-1}, t – the number of hours in a year = 8760 h y^{-1}, F - Conversion factor of absorbed dose in air to effective dose = 0.7 (Sv Gy^{-1}), T = The indoor occupancy factor.

External exposure to gamma radiation from natural radioactive elements occurs both indoors and outdoors. For calculation of annual dose it is important to take into account the occupancy factor. Here it is assumed that people spend 20% of their time outdoors and 80% indoors on an average worldwide (UNSCEAR, 2008). Hence the indoor occupancy factor T is taken as 0.8.

The absorbed dose rate (D) can be expressed as a sum of contributions from the different radionuclides in the building material (Equation 8).

$$D = q_{Ra}C_{Ra} + q_{Th}C_{Th} + q_k C_k \qquad (8)$$

Where, C_{Ra}, C_{Th} *and* C_K are the specific activities in Bq kg^{-1} of ^{226}Ra, ^{232}Th and ^{40}K respectively, q_{Ra}, q_{Th}, q_k are the factors for converting the radioactivity concentrations in a building material to the

absorbed dose rate in air and at 1 m distance away from the surface of the material (Interim report, The Netherlands, 1985).

$$q_{Ra} = 620 \times 10^{-9} \text{ mGy h}^{-1}/\text{Bq kg}^{-1}$$

$$q_{Th} = 890 \times 10^{-9} \text{mGy h}^{-1}/\text{Bq kg}^{-1}$$

$$q_{k} = 54 \times 10^{-9} \text{ mGy h}^{-1}/\text{Bq kg}^{-1}$$

Results and Discussion

Specific activity

The specific activities of ^{226}Ra, ^{232}Th and ^{40}K were determined for all the studied cement samples and raw materials of cement. The mean specific activity values of these radionuclides with the statistical uncertainty are presented in Table 2 and Table 3 respectively. These results are also shown graphically in Figure 1 and Figures 2, 3 and 4.

Table 2: The range and the mean specific activities with uncertainty of ^{226}Ra, ^{232}Th and ^{40}K of all types of cement samples in Bq kg^{-1}

Type of Cement		^{226}Ra (Bq kg^{-1})	^{232}Th (Bq kg^{-1})	^{40}K (Bq kg^{-1})
CEM-1 OPC 1	Mean	27.9 ± 0.7	25.1 ± 0.9	99.5 ± 4.2
	Max.	33.7 ± 2.3	29.4 ± 3.5	126.6 ± 13.6
	Min.	20.8 ± 2.0	18.7 ± 2.6	50.6 ± 13.3
CEM-II PLC	Mean	26.5 ± 0.6	23.4 ± 0.8	93.3 ± 3.5
	Max.	29.5 ± 1.9	26.2 ± 2.9	103.9 ± 11.9
	Min.	22.8 ± 1.9	20.9 ± 2.6	62.5 ± 10.5
CEM-III PPC 1	Mean	66.8 ± 1.2	62.1 ± 2.3	131.5 ± 5.9

	Max.	71.3 ± 2.8	68.9 ± 6.3	168.3 ± 14.6
	Min.	62.7 ± 2.9	57.7 ±5.7	103.2 ± 13.1
CEM-IV OPC 2	Mean	44.9 ± 0.9	23.0 ± 1.3	226.4 ± 6.7
	Max.	46.2 ± 2.2	26.7 ± 3.1	240.5 ± 14.9
	Min.	42.4 ± 2.2	19.4 ± 2.4	209.3 ± 15.2
CEM-V OPC 3	Mean	23.1 ± 0.8	28.8 ± 1.2	239.9 ± 5.7
	Max.	25.5 ± 1.9	31.7 ± 2.9	258.5 ± 12.5
	Min.	19.9 ± 1.9	26.3 ± 2.4	224. 4 ± 12.3
CEM-VI PPC 2	Mean	32.4 ± 0.7	32.8 ± 1.2	179.5 ± 3.8
	Max.	52.9 ± 2.6	43.0 ± 3.6	220.1 ± 11.6
	Min.	18.7± 0.9	20.4±2.2	158.5± 12.5
CEM-VII OPC 4	Mean	47.5 ± 0.9	22.8 ± 1.2	185.5 ± 5.3
	Max.	49.0 ± 2.1	24.5 ± 2.6	197.8 ± 11.4
	Min.	46.5 ± 2.1	21.0 ± 2.6	174.1 ± 11.6
CEM-VIII Imported OPC 1	Mean	29.1 ± 0.9	20.6 ± 1.1	102.8 ± 4.9
	Max.	29.8 ± 2.1	25.0 ± 2.5	110.8 ± 10.6
	Min.	28.6 ± 1.9	18.8 ± 2.3	82.4 ± 11.4
CEM-IX Imported OPC 2	Mean	40.9 ± 0.9	25.7 ± 2.1	195.2 ± 5.6
	Max.	44.2 ± 2.2	28.4 ± 3.2	218.4 ± 12.5
	Min.	38.6 ± 2.1	24.1 ± 2.6	174.6 ± 12.5

CEM-X Imported OPC 3	Mean	21.4 ± 0.9	13.8 ± 0.9	83.7 ± 4.9
	Max.	23.5 ± 1.8	15.6 ± 1.8	102.2 ± 10.4
	Min.	19.5 ± 1.9	12.5 ± 1.8	72.9 ± 10.8
CEM-XI Imported PPC 1	Mean	55.9 ± 1.1	41.4 ± 1.8	152.3 ± 5.6
	Max.	56.6 ± 2.1	43.2 ± 4.3	159.7 ± 13.6
	Min.	54.1 ± 2.1	39.6 ± 3.9	138.3 ± 1.0

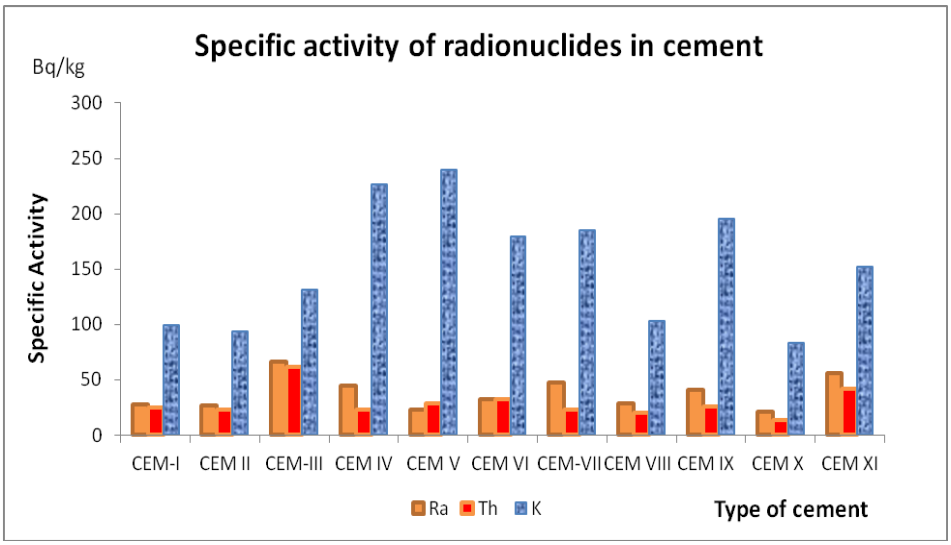

Figure 1: Mean Specific activities of radionuclides in cement samples

As can be seen from Table 2 and Figure 1 the specific activities of 226Ra and ^{232}Th were maximum in CEM-III PPC 1 cement. The specific activity of ^{226}Ra was found in the range 21.4 ± 0.9 to 66.8 ± 1.2 Bq kg^{-1} for all cement samples. For ^{232}Th it was found in the range 13.8 ± 0.9 to 62.1 ± 2.3 Bq kg^{-1}. The lowest value for ^{226}Ra and ^{232}Th were observed in CEM-X imported OPC 3 cement.

In the case of ^{40}K, the CEM-V OPC 3 cement samples showed the highest concentration, whereas, CEM-X imported OPC 3 cement samples showed the lowest concentration. The highest and the

lowest concentrations were 239.9 ± 5.7 Bq $kg^{-1}$and 83.7 ± 4.9 Bq kg^{-1} respectively.

According to the results shown in Table 3 and Figures 2, 3 and 4 the concentrations of ^{226}Ra,^{232}Th and ^{40}K in fly ash are much higher than that of the other raw materials. About 25% and 20% fly ash is added to CEM-III PPC 1 cement and CEM-VI PPC 2 cement respectively during manufacturing. About 5 % of fly ash is added to CEM-IV OPC 2 cement and about 2% of fly ash is added to CEM-V OPC 3. The reason for the highest specific activities of ^{226}Ra and ^{232}Th in the CEM-III PPC 1 cement is that it contains 25% of fly ash produced by combustion of coal. The power plant uses different types of coal and had used Indonesian coal during the period of samples of this brand of cement were collected.

CEM-IV OPC 2 cement samples were collected in June 2013. During this period the power plant used a mixture of South African and Indonesian coal. The specific activities of radionuclides in fly ash emitted during combustion of the mixture of South African and Indonesian coal was higher than what was produced from Indonesian coal. Therefore, a higher concentration of ^{226}Ra was found in CEM- IV OPC 2 cement than some other local brands of cement.

The worldwide average specific activities of ^{226}Ra, ^{232}Th and ^{40}K in the Earth's crust were estimated as 32, 45 and 412 Bq kg^{-1} respectively (UNSCEAR, 2008). In all the studied cement samples except in CEM-III PPC 1 the specific activities of ^{232}Th were below the world average value. For all cement samples, the specific activity of ^{40}K was below the world average value. As can be seen in Table 2 the specific activity of ^{226}Ra in some brands of cement were higher than the world average value of 32 Bq kg^{-1}.

Table 3 shows the mean specific activities of ^{226}Ra, ^{232}Th and ^{40}K in Bq kg^{-1}, for the raw material samples, clinker, gypsum, dolomite and limestone collected from a cement factory.

Table 3: Mean specific activities with uncertainty of ^{226}Ra, ^{232}Th and ^{40}K for the raw materials used in cement samples.

Type of raw material	^{226}Ra (Bq kg^{-1})	^{232}Th (Bq kg^{-1})	^{40}K (Bq kg^{-1})
*Fly ash-1	73.9 ± 1.7	71.7 ± 4.9	357.4 ± 10.7
*Fly ash-2	63.4 ± 1.9	66.9 ± 3.4	189.9 ± 10.2
*Fly ash-3	144.7 ± 1.6	115.9 ± 1.5	422.2 ± 7.6
Clinker	27.5 ± 0.8	30.5 ± 1.3	64.9 ± 4.2
Gypsum	1.6 ± 0.2	2.2 ± 0.3	21.4 ± 2.7
Limestone	11.4 ± 0.9	12.2 ± 0.9	38.7 ± 5.1
Dolomite	2.8 ± 0.5	0.6 ± 0.0	1.62 ± 0.1

**Fly ash-1 (fly ash emitted from burnt Indonesian coal)*

**Fly ash-2 (fly ash emitted from burnt mixture of Indonesian and South-African coal)*

**Fly ash-3 (fly ash emitted from burnt mixture of South-African and Russian coal)*

The specific activities of radionuclides were significantly higher in fly ash than the other raw materials. The specific activities of ^{226}Ra and ^{232}Th in raw materials other than fly ash were lower than the world average of 50 Bq kg^{-1} for building materials (UNSCEAR, 1993). It was observed that for all raw materials the specific activity of ^{40}K was less than the world average value of 500 Bq kg^{-1} (UNSCEAR, 1993).

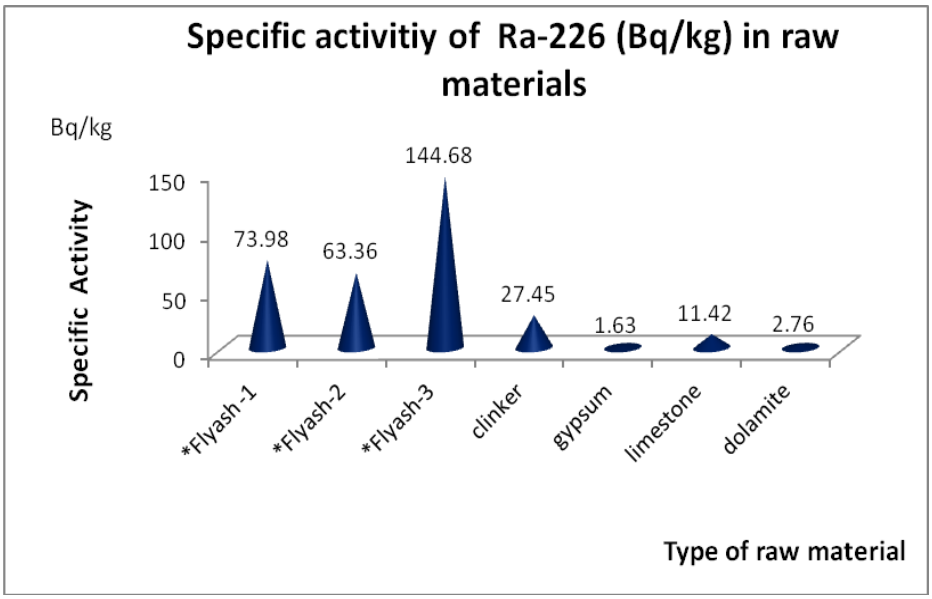

Figure 2: Mean Specific Activities of ^{226}Ra in raw material samples

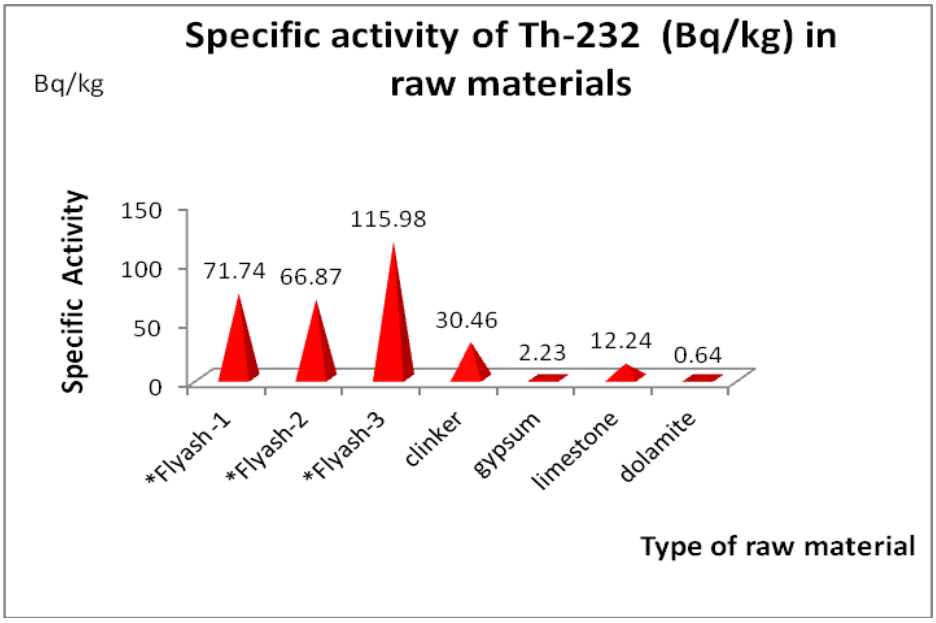

Figure 3: Mean Specific Activities of ^{232}Th in raw material samples

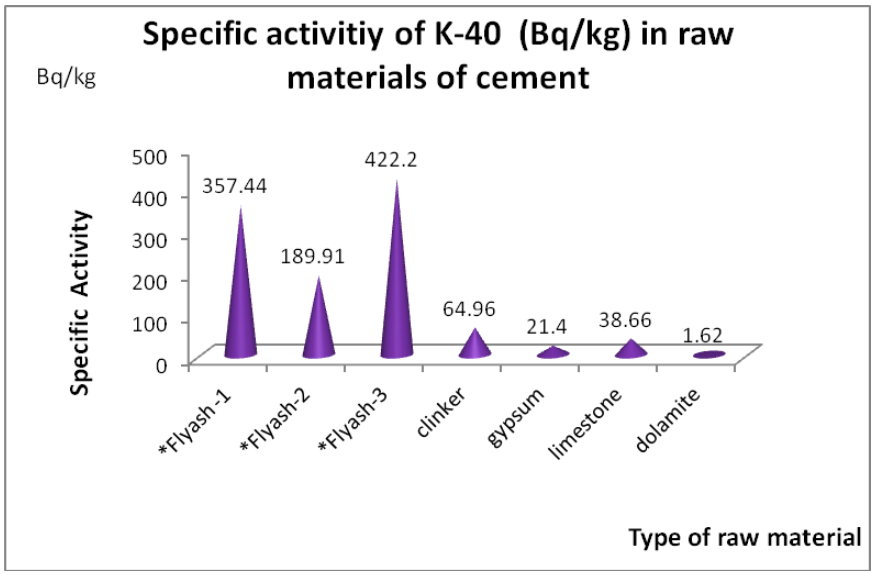

Figure 4: Mean Specific Activities of ^{40}K in raw material samples

According to the Table 3 and Figures 2, 3 and 4 the highest concentrations of radionuclides was observed in fly ash samples. The concentrations of radionuclides were very low in gypsum and dolomite samples.

The specific activities of ^{226}Ra, ^{232}Th and ^{40}K in Bq kg^{-1} obtained for some kinds of raw materials in some countries are shown in Table 4.

Table 4: Comparison of specific activities of the radionuclides in raw materials considered for the present study with those from other countries.

Country	No. of samples	Raw material	^{226}Ra Bq kg^{-1}	^{232}Th Bq kg^{-1}	^{40}K Bq kg^{-1}	Reference
Denmark	7	gypsum	10	07	n.m.	(UNSCEAR, 1982)
	10	fly ash	150	90	n.m.	(UNSCEAR, 1982)
	13	clinker	66	55	n.m.	(UNSCEAR, 1982)
Italy	n.m.	limestone	11	2	22	(Rizzo et al., 2001)
	n.m.	gypsum	6.0	2.0	32	(Rizzo et al., 2001)

Germany	23	gypsum	< 19	<11	n.m.	(UNSCEAR, 1982)
	28	fly ash	211	130	n.m.	(UNSCEAR, 1982)
Poland	106	fly ash	63-610	33-320	n.m.	(UNSCEAR, 1982)
United kingdom	73	gypsum	22	07	n.m.	(UNSCEAR, 1982)
Bangladesh	n.m.	limestone	68	107	1660	(Alam et al., 1999)
		gypsum	255	21.4	121	Chowdhury et al.,
Egypt	n.m.	limestone	20.4	4.4	19.3	(Ahamed and Hussein, 1998)
		gypsum	31.7	55	89	(El-Taher,
Brazil	n.m.	limestone	24.3	7.0	205	(Malanka et al.,
		gypsum	6.3	n.d.	154	(Malanka et al.,
Saudi Arabia	n.m.	limestone	28.6	49.2	66	(El-Taher,
		gypsum	33.3	47.2	88	(El-Taher,
Turkey	128	Limestone	16.5	7.7	88.1	(Turhan, 2008)
		fly ash	232.3	117.1	466.2	(Turhan, 2008)
		Gypsum	10.8	3.6	44.5	(Turhan, 2008)
Present study	30	fly ash	94.0	84.8	323.	
		Gypsum	1.63	2.23	21.4	
		Limesto	11.4	12.2	38.6	
		Clinker	27.4	30.4	64.9	
		Dolomit	2.76	0.64	1.62	

(n.m – not calculated; n.d.– not detected)

It can be seen from Table 4, that the radioactivity in raw materials used for manufacturing cement varies from one country to another.

The values given in this table were not the representative values for the countries mentioned, but they were typical for the regions where samples were collected. Table 4 also shows that specific activity of ^{226}Ra and ^{232}Th in fly ash considered in the present study is lower than those of other countries.

The mean values of specific activities of ^{226}Ra,^{232}Th and ^{40}K calculated for cement samples for the present study and the corresponding values determined by other countries are shown in Table 5.

Table 5: Comparison of specific activities (Bq kg^{-1}) of radionuclides in Sri Lankan made cement samples with the published data of other countries.

Country	No.of samples	^{226}Ra Bq kg^{-1}	^{232}Th Bq kg^{-1}	^{40}K Bq kg^{-1}	Reference
Australia	7	51.5	48.1	114.7	(Bereka and Mathew,
Austria	18	26.7	14.2	210.0	(Sorantin and Steger,
Algeria	12	41.0	27.0	422.0	(Amarani and Tahtat,
Bangladesh	18	62.3	59.4	328.9	(Chowdhury et al., 1998)
Brazil	1	61.7	58.5	564.0	(Malanka et al., 1993)
China	46	56.5	36.5	173.2	(Xinwei., 2005)
Egypt	85	78.0	33.3	37.0	(El Afiafi, 2006)
Finland	11	40.0	20.0	251.0	(Mustonen, 1984).
Ghana	50	35.94	25.44	233.0	(Kpeglo, 2011)
Greece	20	62.8	23.8	284.1	(Papastefanou, 2005)
India	1	37.0	24.1	432.2	(Kumar, 1999)
Italy	7	38.0	22.0	218.0	(Rizzo et al., 2001)

Japan	16	35.8	20.7	139.4	(Suzuki et al., 2000)
Netherlands	6	27.0	19.0	230.0	(Ackers et al., 1985)
Pakistan	25	26.7	28.6	272.9	(Khan and Khan, 2001)
Tunisia	2	21.5	10.1	175.5	(Hizem et al., 2005)
Turkey	145	40.0	28.0	248.3	(Turhan, 2008).
Sri Lanka	65	38.5	31.8	165.0	

According to Table 5 the mean specific activity values for cement samples taken from different countries shows considerable variation. The reason for this is the type and different proportions of raw materials used in cement manufacturing.

Assessment of radiation hazard

The radiation hazard caused by cement used in Sri Lanka was determined by the radiological parameter, the annual effective dose rate (A.E.D). Table 6 shows the calculated values of this parameter and the absorbed dose rate for the different brands of cement studied.

Table 6: Annual effective dose rates and absorbed dose rates for cement samples.

Type of cement	Absorbed dose rate in air (nGy h^{-1})	A.E.D. (mSv y^{-1})
CEM-1 OPC 1	45.01	0.22
CEM-II PLC	42.23	0.21
CEM-III PPC 1	103.85	0.51
CEM-IV OPC 2	60.57	0.30
CEM-V OPC 3	53.03	0.26
CEM-VI PPC 2	58.93	0.29
CEM-VII OPC 4	60.27	0.31

CEM-VIII Imported OPC1	42.23	0.21
CEM-IX Imported OPC 2	59.09	0.29
CEM-X Imported OPC 3	30.02	0.15
CEM-XI Imported PPC 1	79.42	0.39

The Annual effective dose inside the reference room considered was calculated by using Equation 7. The calculated values for different cement samples are shown in Table 6. The estimated average annual effective dose ranged from 0.15 to 0.51 mSv y^{-1} and less than the recommended maximum permissible public dose 1.0 mSv y^{-1} (International Basic Safety, IAEA, 1996).

Conclusion

From the results it is evident that there are considerable variations in the specific activities of radionuclides ^{226}Ra, ^{232}Th and ^{40}K in raw materials. The highest concentrations of these radionuclides were observed in fly ash.

The concentrations of radionuclides in the samples of different brands of cement were not same. The highest values of ^{226}Ra and ^{232}Th were observed in CEM-III PPC-1 cement where 25% fly ash was added, whereas the minimum values of ^{226}Ra, ^{232}Th and ^{40}K were in CEM -X imported OPC 3 cement. The highest concentration of ^{40}K was observed in CEM-V OPC 3 cement. These variations are due to the varying amounts of ^{238}U, ^{232}Th and ^{40}K in the raw materials and different proportions of the raw materials used in manufacturing different brands.

It was observed that the annual effective dose values for all the studied samples were lower than the recommended maximum permissible public dose of 1.0 mSv y^{-1}. All the cement samples studied did not show any significant radiation hazard and could be considered safe for construction work.

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Analysis of the Problems of and the Suitable Solutions for an Initial Teacher Training Programme Conducted through the Distance Mode

Galappaththige Dayalatha Lekamge[1]*, Ayomi Indika Irugalbandara[2], Meregngnage Nadeesh Chandana Fernando[3]

[1,2,3]Department of Secondary and Tertiary Education, Faculty of Education, The Open University of Sri Lanka, Nawala, Sri Lanka

Abstract

Good teachers must be made. Many countries have adopted different models of Distance Education to provide initial training to unqualified teachers, expand opportunities for professional development of in-service teachers and increase awareness of teachers on educational reforms. Whatever the models used, all Distance Education providers are faced with challenging tasks in co-ordinating partners and agents in teacher education programmes where practical teaching and its assessment is involved (Robinson and Latchem, 2003:40). The Open University of Sri Lanka (OUSL), as a pioneering institution to introduce teacher training programmes through the Distance Mode, also has confronted problems in line with an initial training programme aimed at producing drama and theatre teachers to the school system. Thus, a comprehensive study has been carried out with a view to obtain an insight into the problems faced by different stakeholders, their root causes, and to uncover workable solutions

**Correspondence should be addressed to Prof. G. D. Lekamge.*
Email: *gdlek@ou.ac.lk*
https://orcid.org/0000-0003-1594-1439

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within the context of Distance Education. Data was collected from three batches of student-teachers who have completed the programme, lecturers, co-ordinators, master teachers and some experts in the field and analyzed using both quantitative and qualitative techniques. The study sheds light on meaningful solutions to be applied for improving the quality of the programme concerned.

Keywords: Distance Mode, Initial Training, Problems and solutions

Introduction

Good education demands good teachers. Good teachers are not born but must be made. The importance of teachers in determining the quality of education is emphasized by many international reports (UNICEF,1999; UNESCO, 2000a; OCED, 2001) and education and training of teachers was identified as one of the indicators of the quality of the school system (UNESCO Institute for Statistics, 2001). As estimated by UNESCO Institute of Statistics, about 69 million teachers must be recruited to achieve universal primary and secondary education by 2030. To cope with such demands, many countries have introduced Distance Education for initial training of unqualified teachers, continuing professional development of in-service teachers and for awareness raising of teachers about curricula and other reforms. The research studies conducted elsewhere on training prospective teachers through the Distance Mode have reported mixed findings. The present study is directed to identify the strengths and limitations of an initial teacher training programme conducted through the Distance Mode and to make recommendations on possible interventions for improving quality.

Pertinent Literature

Initial teacher education and training is the basic or first level of qualification for a teacher. It may be taken as Pre-Service Teacher Education (PSTE: before a trainee teacher begins work as a teacher) or an in-service one (while an untrained teacher works as a teacher). The pre-service programs are also regarded as foundational building blocks for career-long professional development (Darling-Hammond,

1996). Further, the quality of training provided through PSTE programs affects teachers' practice, effectiveness, and career commitment (Eren & Tezel, 2010). The quality of teaching and learning taking place in the classroom, therefore, depends on and reflects the quality of PSTE programs.

The major use of Distance and Open Education has been for initial teacher training, especially for primary teachers, and as a means of providing unqualified serving teachers with a qualification (Moon and Robinson, 2003; 72). Three case studies reported by UNESCO (2001) show three different models followed by the countries to facilitate initial training of teachers. As per the report, Distance Education had been used as an alternative route to primary teacher qualifications by the Nigerian government, and the television had been used to reach teachers who were in distant and remote places in China. As the third case study, it was pointed out that the United Kingdom offered a Post Graduate Certificate in Education (PGCE) programme using Information & Communication Technology (ICT) to support a school-based initial teacher education progrmme. In addition, Perraton (1993) reported about two pre-service and six in-service initial training programmes conducted by eight different countries, namely, Tanzania, Zimbabwe, Sri Lanka, Indonesia, Nigeria, Pakistan, Nepal and Brazil using a variety of Distance Education methods.

However, through an in-depth analysis of those case studies, it could be revealed that the use of Open and Distance Education for initial teacher training has generated both positive and negative outcomes. On the one hand, those programmes were able to reach teachers in a large scale within a shorter period of time than institutional based alternatives (Robinson & Latchem, 2003). On the other hand, the completion rates and drop-out rates were high in those programmes when compared with face-to-face programmes. It was further revealed that Distance Education experiences in several countries have met with mixed success in providing either the knowledge of subject matter or development of pedagogical skills (Dove, 1986; Mahlck & Temu, 1989; Nielsen & Tatto, 1991; Taylor, 1983). While the developing countries extensively apply Distance Education for providing initial training to their teachers, the developed countries like the United Kingdom have not adapted Distance Education for

professional training due to difficulties in managing initial teacher training using the Distance Mode (Waker,2007). A comparative study conducted in Pakistan (Parveen, 2010) revealed that there was no difference in efficacy of B.Ed graduates trained using the regular mode and Distance Mode though subject knowledge, subject application, teaching strategies and classroom management skills were higher in regular graduates than distance-based graduates. The findings further revealed that regular graduates spend more time on learning, have regular contact with their teachers and clear understanding on teaching strategies applicable to their subjects than distance-based graduates. In Zimbabwe, a recent study concluded (Mubika & Bukalia, 2013) that the limitations in the delivery system of a distance-based teacher education programmes had created several issues that had implications for the quality of the teachers produced.

The emphasis placed on subject knowledge, professional studies and practice differs from one programme to an another and they have been criticized for weak integration of theory and practice, poor quality and inadequate time for school practice (Moon and Robinson, 2003; 76). The case studies illustrated by Perraton (1993) supported the idea that Distance Education has been successful in reaching out to teachers who are scattered over huge distances and producing a large number of trained teachers without removing them from their work places. However, Robinson (1997:125) concluded: "Not all courses worked well or provided good quality though enough have to demonstrate the capacity of distance education for training and educating teachers and for enabling new models of training to be explored". Therefore, it is questionable whether the Distance Education programmes have the capability to produce quality teachers to the education system.

Bachelor of Education (B.Ed) in Drama and Theatre Programme of The Open University of Sri Lanka

The B. Ed in Drama & Theatre programme was initiated by the Faculty of Education of the OUSL in 2010 with a view to cater to the demand arising from the school system and it was offered in collaboration with the Tower Hall Theatre Foundation. The students who complete the Higher National Diploma of Tower Hall Theatre Foundation get the

opportunity to enroll in the B.Edprogramme. The Higher National Diploma is a two-year full-time programme (Level 3-4 of B. Ed) through which the students get sufficient knowledge and skills in different areas of drama and theatre, such as performing, designing, lighting and costumes for drama, producing drama etc. However, they neither have prior knowledge on education nor experience in teaching by the time they enroll in the Level 5 of the B. Ed programme at the OUSL.

By now, two batches of students (23 + 43) have already passed out (in 2014 & 2015) and another batch (20) was at the final stage in their programme in 2016. There are two batches of students, 16 and 32 respectively, continuing at Level 5 and Level 6 of the programme. With the two batches who have already completed the programme, and with the third batch, the Faculty witnessed critical problems in meeting the standards of an initial teacher training programme conducted at undergraduate level.

In the initial Faculty-level discussions that took place among the programme team members, a concern was raised about the limited professional competencies and low ethical and moral standards exhibited by those student-teachers which would directly affect the quality of the instructional practices adopted by them in classrooms. Further, it was revealed in the discussion that the mismatch between the aims and objectives of the Higher National Diploma and the B. Ed Degree also might lead to deficiencies in their pedagogical knowledge and skills and their commitment to teaching (their priorities are different).The Faculty is very much concerned that the production of low quality graduate teachers to the system would be a critical issue which would definitely have an impact on the quality as well as the demand of the programme and on the reputation of the institution. Therefore, an investigative study was conducted to find out the problems faced by teachers (internal academics) and student-teachers in the programmes and suggest possible solutions to be implemented in the future.

Objectives of the study

To analyze the views of the student-teachers, co-ordinators, lecturers/master teachers with regard to the curriculum,

instructional material, instructional processes adopted in the programme (including assessments and teaching practice) and the quality of the teachers produced

To identify the problems and issues faced by them in relation to curriculum, instructional material and the instructional processes which would hinder the attainment of programme objectives
To make recommendations/solutions for the existing problems faced by different parties involved in the programme.

Methodology

The two batches of student teachers who had passed out from the programme (56), three batches who have been following the programme (78), 10 lecturers who have been playing different roles as course team members, day school academics, tutors and master teachers and the co-ordinators of the programme had been considered as the sample of the study. In addition, the views of two experts about the different aspects of the programme were also collected to get insights into the conducting of the programme.

Multiple methods were used for data collection in order to facilitate triangulation of data. They included, focused group discussions with student teachers, questionnaires filled by student teachers and lecturers, observations and reflective notes of master teachers about the performance of student-teachers in teaching practice and records on assignments and final examinations completed by student teachers. Both quantitative and qualitative techniques were integrated to the analyses of data in this study which included percentages, mean analysis and content analysis.

Data Analysis and Discussion

This section is organized as per the objectives of the study.

(1) Views on the curriculum, instructional material and instructional processes of the programme

Almost all the teachers and student-teachers were in agreement that Level 5 and 6 curricula have a strong emphasis on education courses.

Further, the positive contribution of some courses, such as Educational Psychology, Education Technology, Principles of Education, Teaching Drama & Theatre etc was stressed by teachers (10). The student-teachers also acknowledged the teachers' views though they identified Inclusive Education and Guidance and Counseling as the most relevant subjects for their teaching and wanted to acquire knowledge and skills relating to those subjects (68%). Further, the student-teachers wanted Information Technology and English also to be incorporated in to the curriculum and expected strong concentration on drama and theatre courses at Level 5. Teachers highlighted the importance of incorporating a course to get sufficient opportunities to familiarize themselves with the teaching profession (90%).

With regard to the lesson material, the relevance, user friendliness and readability had come out as outstanding features from both parties. However, teachers themselves had pointed out that some material should be updated to include recent developments of the field (50%). From the point of view of student teachers (58%), more illustrations and elaborations should be incorporated along with simplified versions of the modules to facilitate self-learning. It was surprising to find that the suggestion of teachers to incorporate on-line components to different courses (90%) had not been welcomed by the student teachers as a fruitful strategy.

The academics gave a high rating for the instructional processes adopted by them and introduced the contact sessions (day schools in ODL terminolgy) as a very good platform for maintaining friendly humane interactions with student-teachers and building their self-confidence and self- regulatory behavior (100%). Both categories felt that interactive day schools and practical workshops increased the preparedness of student-teachers towards the task at hand and expanded opportunities for close interactions between the two parties.

Teachers expressed a negative opinion on student-teachers' reactions towards the Day Schools. For instance, they have given a poor rating (mean 2.0) to 'punctuality of student-teachers at day schools' out of the 10 aspects considered, and 'attendance at Day Schools' also had a moderate rating (mean 3.0) in comparison to the other aspects

(Table 1). However, promoting such aspects is somewhat contradictory to the principles followed by the Open and Distance Learning institutions. According to the academics, student- teachers' participation in group activities and in discussions are at a satisfactory level (mean 4.2 and 3.9 respectively). 'Giving prompt answers' (mean 3.2) 'maintaining interaction with other student teachers' (mean 3.3), 'maintaining interaction with the teacher'(3.4) received moderate ratings.

Table 1: Internal Academics' views on student-teachers'

Day Schools	**Mean of ratings**	**Day Schools**	**Means of ratings**
Attendance at Day Schools	3.0	Participation in discussions	3.9
Punctuality at Day Schools	2.0	Asking questions	3.4
Readiness for Day Schools	3.5	Giving prompt answers	3.2
Paying attention to the teacher	3.5	Maintaining one-to-one interaction with teacher	3.4
Participation in group activities	4.2	Maintaining interaction with other student-teachers	3.3

However, the student-teachers' views were different. They requested more Day Schools to facilitate their understanding of the subject matter and close interactions with teachers, the Faculty and colleagues. All student-teachers were of the opinion that the duration of Teaching Practice should be extended, and their progress would be more satisfactory if internal academics (rather than master teachers) could do the supervision during Teaching Practice (TP). Academics also agreed with the expanding of the TP period to provide more opportunities for student-teachers to develop professional skills related to the teaching-learning process. Teaching Practice as a specific strategy incorporated in to the programme had been contributing significantly for the professional development of student teachers though the need for further strengthening it to achieve the standards of the programme was highlighted.

(2) Views on the Quality of the Teachers Produced

Both the academics and student teachers expressed different views on the quality of teachers produced. As specified by the academics, the actor's role strengthened by the Tower Hall Theatre Foundation at Level 3 & 4 overshadowed the "teaching role" of the student-teachers. Those findings could be further supported by using the data gathered through a self-administered questionnaire (Table 2) from teachers.

Table 2: Viewsof the the teachers on the student-teachers' knowledge exhibited through Teaching Practice

Knowledge areas	**Mean of rating**	**Knowledge Areas**	**Means of ratings**
Knowledge of principles of learning	3.0	Knowledge of teaching Drama & Theatre	3.8
Knowledge of the development levels of students	2.8	Knowledge of the learning environment	3.0
Knowledge of student variability and exceptionality	2.5	Knowledge of using blackboard	2.9

As illustrated in table 2, 'knowledge of teaching drama and theatre' is the only area for which a high rating was received (mean- 3.8) from the teachers in the five-point scale ('poor' to 'excellent'). The reasons might be the strong emphasis placed on integrating theory of drama & theatre with the practice. 'Knowledge of the development levels of students' and 'knowledge of student variability and exceptionality' received lower ratings than the other four areas, which require urgent attention of the Department.

Table 3 depicts their skills in the teaching-learning process.

Table 3: Views of the academics on the student teachers' skills exhibited in Teaching Practice

Skill areas	**Means of rating**	**Skills areas**	**Means of ratings**
Skills in using blackboard	2.8	Skills in conducting group activities	3.1

Skills in using other learning aids	3.1	Skills in interacting with students	3.3
Skills in presenting lessons	3.1	Skills in promoting interactions among students	3.3
Skills in motivating students	3.1	Skills in using classroom assessments	2.6
Skills in getting attention of students	3.3	Skills in managing time	2.6

The lowest ratings were received for 'skills in using blackboard' (2.8) 'skills in using classroom assessments' (2.6) and 'skills in managing time' (2.6). Those skills are very important for a teacher to complete a lesson in an effective manner. Even for the other seven areas indicated in the Table 3, the ratings remained at a marginal level (3.1 to 3.3). Reflections of the academics during the TP period further confirmed the situation identified through the questionnaires.

Table 4: Summary of the reflections on preparation of lessons of the student-teachers

Aspects	**Mean of ratings**
Forming suitable Objectives in their lessons	**3.0**
Planning correct and relevant methods	**3.1**
Identifying and developing effective teaching aids	**3.2**
Preparing the classroom environment	**2.7**
Planning assessment methods	**2.5**

Table 5: Summary of the reflections on presentation of lessons of the student-teachers

Beginning of the lesson- first 5 minutes	**Mean of ratings**
Applying suitable techniques	**3.5**
Using appropriate words	**3.5**
Getting attention of students	**3.7**

Arousing motivation of students	**3.3**
Presenting the lesson- 5-25 minutes	
Applying suitable teaching methods	**2.7**
Using appropriate Teaching Aids	**2.5**
Promoting interaction with students	**3.5**
Promoting interaction among students	**3.6**
Maintaining student attention	**3.5**
Maintaining student motivation	**3.8**
Linking different parts of the lesson	**2.5**
Managing time effectively	**2.5**

The teachers were asked to focus on three lessons out of the five lessons they had observed and write down their assessments according to the five-point scale given and a separate column was provided in the same sheet to write down detailed reflections. The assessments of all three lessons were considered for the above calculations.

As the majority pointed out, the beginning of lessons of student-teachers were somewhat satisfactory (means varied from 3.3-3.7) and the majority applied different techniques such as songs, activities, role plays, blackboard, teaching aids, facial expressions etc through which they were able to get the attention and arouse the motivation of students. However, in the middle of the lessons their performance was poor in relation to 'applying suitable teaching methods' (mean 2.7)and 'techniques' (mean 2.5) , 'linking different parts of the lessons' (mean 2.5) and 'managing time effectively' (mean 2.5).

The following open-ended answers provided by the teachers also confirm the above situation:

"Teaching is not done per the lesson plan. Language needs to be improved. Use of black board is good and singing and dancing perfect"
"Use of technology is excellent, Student teachers have shown good teaching abilities, but need to use student-centered methods to improve effectiveness of their teaching

"Need to adjust to the lesson, need more practice. Confidence to be improved to make the teaching -learning process more effective"
"Need more training on organization and management skills. Poor time management skills were exhibited"

Overall, the teachers felt that the teaching skills of the student-teachers must be improved to provide fruitful learning experiences to their students. Further, when compared with the ratings given to the three lessons, a significant positive change was not visible. However, the viewpoints of the student-teachers were somewhat contradictory to the views of their teachers. The majority expressed high confidence about their performance during the TP period and stressed that they could have done better if more support from the institution and schools, and more time for Teaching Practice, were provided. The following are some open-ended answers given by the student teachers at the focus group discussions:

"We are new to schools and new to teaching. So, training should be gradually done to give the full responsibility at the end. We need to have a transition period".

"Teaching Practice time is not sufficient. We need more time to familiarize with the school environment".

"We need a longer period to adjust to a school. Need opportunities to be familiar with the school set up"
"More model teaching should be provided and TP to be continued from Level 5".

"We need more opportunities to observe teaching-learning situations of exemplary teachers"

"Comprehensive feedback should be provided on our teaching on the spot"

"Need more experience to handle teaching learning situations individually and as a group"

The above data revealed that both teachers and student's teachers had somewhat similar opinion about the curriculum and instructional material of the programme though their views were different with regard to the quality of the teaching-learning process.

(3) Problems highlighted and solutions proposed by the teachers and student-teachers

Some of the crucial problems which emerged from the responses of teachers and student-teachers and the solutions proposed by them could be summarized as follows. The answers are summarized under themes to produce Table 6.

Table 6: Problems highlighted and solutions proposed by teachers and student-teachers

	Problems highlighted	**Solutions proposed**
Curriculum	Curriculum is biased towards Education courses- Narrow focus on drama and theatre (T) Limited focus on developing 21st century professional skills/soft skills (T) Lack of opportunities to integrate theory with practice (ST) Traditional nature of the curriculum- challenging experiences are minimal (ST)	Introduction of new courses at Level 5 and 6: Compulsory course titled "Introduction to Teaching Profession" Optional courses on "Methods of Teaching Dancing / Methods of Teaching Art /Methods of Teaching Music" etc. (T) Integrate Drama and Theatre courses in Level 5 & 6 (ST) Introduce English and ICT courses (ST)
Material	Limited use of AV material (T) Outdated information (T) Self –learning not practiced (T) Students pay limited attention to activities (T) Self-study is difficult (ST) No illustrations and elaborations (ST) Completion of activities take time (ST)	Material should be revised (T) On-line interaction to be promoted (T) More AV material to be introduced (T) Need more illustrations &simplified versions of modules (ST) Face-to-face interaction to be expanded (ST) Facilities to be provided for group learning (ST)
Day Scho	Students do not consider Day Schools as supplementary to material (T)	Interactive sessions should be increased (T)

	Poor preparedness of students for Day Schools (T) Limited involvement of senior academics (ST) Limited number of Day Schools (ST) Difficulty in traveling a long distance as programme offered only in the main centre (ST)	New innovative teaching methods to be implemented at day schools (T) Participation to be made compulsory (T) Need exemplary models to follow (ST) Increase the number of day schools (ST) Facilities to be provided for peer interactions (ST)
Teaching Practice	Limited experience in applying theory (T) Limited understanding on student diversities (T) Limited understanding on the variety of Teaching Learning aids/methods (T) Inadequate orientation to teaching (ST) Duration of Teaching Practice not sufficient (ST) Need more support from schools/ mentors/ master teachers (ST) Limited monitoring and supervision (ST)	Teaching Practice period to be expanded (T) More exposure to be provided in actual classrooms under the guidance of academics (T More exemplary modules to be provided (T) Supportive culture to be developed in schools through school mentors (T) Proper mechanism to monitor progress of Teaching Practice (ST) Internal academics should supervise teaching practice
Quality of Teachers	Perform actors' role but not teachers' role -Actors stimulate emotions: Teachers help students to control emotions (T) Expressed concern about ethical conduct of teachers (T) No supportive culture at schools (T) Lack of opportunities to develop professional competencies (ST) Limited exemplary models to follow (ST)	School mentors' role to be further improved(T) Internal academics should be involved in evaluating TP (T) More familiarization with school activities during two years (T) Time period of Teaching practice to be expanded (T) Procedures to be adopted to get maximum support from schools (ST)

	Lack of support from the school mentors and master teachers (T)	More exemplary models to be provided (ST) Proper standards to be identified for teacher education programmes (T)

Key- T- Teachers' responses ST – Student-Teachers' responses

The main problem which emerged through the analyses of responses was related to the quality of teachers produced. The sub-problems relating to it could be identified as the actor's role practiced prior to teaching (promoted in the Higher National Diploma), limitations in the programme curriculum and instructional material, duration of teaching practice, limited support provided by the school, limited interactions with internal academics and the institution etc (Table 6). The purpose of using lesson material was lost and prospective teachers preferred Day Schools to material and teacher-guided instructions to independent learning.

Conclusions and Recommendations

Both teachers and student teachers had somewhat similar perceptions about the curriculum, instructional material and instructional processes adopted in the programme.

Poor quality material, limited emphasis on the drama and theatre in the curriculum, limited use of technology for teaching and learning and insufficient number interactive sessions could be identified as the main problems of student-teachers. Teachers were worried about the mechanism adopted for the development of professional skills of student-teachers as well as the limited support provided for them during the Teaching Practice period.

As solutions to these problems, several recommendations could be made through the findings of this study. It is proposed that new innovative method should be applied for contact sessions to integrate theory with practice and more opportunities should be provided for close interactions between teachers and student teachers. Further,

learning about teaching requires meaningful relationships between schools, pre-service teacher education institutes, and pre-service teachers (Korthagen, Loughran, & Russell, 2006). Therefore, a supportive culture within the school system and institution should be strengthened to sustain interface between teaching activities and learning behaviors of student- teachers. Further, a proper mix of human contact and technology should be provided to produce quality teachers through the programme.

Two other important recommendations would be that the expansions of the length of the Teaching Practice period and the change of the role from the "actors' role" to real teachers' role. Finally, it is proposed that a framework should be developed to assure standards of teachers produced through the programme. It could be concluded that the findings of the present study are somewhat different from the findings of the previous studies. As reported by Tatto & Kularathne (1993) the graduates of Distance Education programmes were as successful (and in some cases even more successful) as the graduates of the more conventional programmes - namely pre-service and traditional in-service programmes. So, there is an urgent need to introduce a complete revision to the programme with a view to strengthen the quality of teachers produced.

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