FORENSIC DETERMINATION OF DRUG TABLETS UPON EXTERNAL EXPOSURES

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FORENSIC DETERMINATION OF DRUG TABLETS UPON EXTERNAL EXPOSURES

by

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of the requirements for the degree

of Master of Science (Forensic Science)

September 2020

CERTIFICATE

This is to certify that the dissertation entitled

"FORENSIC DETERMINATION OF DRUG TABLETS UPON EXTERNAL EXPOSURES"

is the bona fide record of research work done by

NOORSHUHAIDA BINTI MUHAMAD SUFRI

during the period of February 2020 to September 2020 under my supervision. I have read this dissertation and that is my opinion in it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfilment for the degree of Master of Science (Forensic Science).

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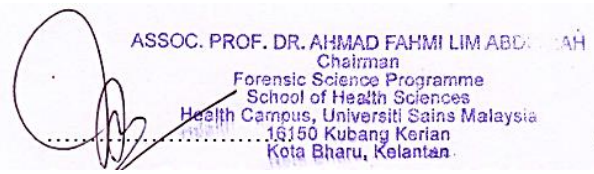

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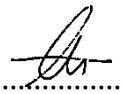
DECLARATION

I hereby declared that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declared that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.



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LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
°C	Degree Celcius
Am	Ante meridiem
AMEAP	Africa, the Middle East and the Asia and the Pacific
AQIM	Al-Qaeda in the Islamic Maghreb
ASEAN	Association of Southeast Asian Nations
ATR-FTIR	Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy
ATS	Amphetamine-Type Stimulants
CBP	Custom and Border Protection
CMEA	Combat Methamphetamine Epidemic Act
COVID	Coronavirus disease
CRIMJUST	Criminal Justice
CSP	Cocaine Signature Programs
DEA	Drug Enforcement Administration
DOD	Department of Defence
et al	*et alia* – and others
FSPP	Fentanyl Signature Profiling Program
HCA	Hierarchical Cluster Analysis
HSP	Heroin Signature Programs
IR	Infrared
Kg	Kilograms
LSD	Lysergic Acid Diethylamide
Mal	Malaysian Flag

Mg	Milligram
mL	Millilitre
Mm	Millimetre
NFLIS	National Forensic Laboratory Information System
NPS	New Psychoactive Substance
P-650	Panadol 650
PCA	Principle Component Analysis
pt	Point
SM	SM Pharmaceuticals
SWB	Southwest border
t-BOC	ter-butyl methyl (1-phenylpropan-2-yl) carbamate
TCO	Transnational Criminal Organizations
U.S	United States
UNODC	United Nations Office on Drugs and Crime
ZnSe	Zinc Selenide

PENENTUAN FORENSIK TERHADAP TABLET DADAH DENGAN PENDEDAHAN LUARAN

ABSTRAK

Tablet farmaseutikal adalah sejenis dos preskripsi yang merangkumi komponen aktif bahan ubat dengan bahan cair yang sesuai. Pendedahan ubat terhadap faktor persekitaran, seperti kelembapan, panas dan tekanan, berkemungkinan boleh merosakkan produk serta mengubah sifat fizikokimia ubat. Perubahan tersebut boleh mempengaruhi keselamatan dan keberkesanan ubat tersebut. Kajian ini bertujuan untuk menyiasat kesan pendedahan persekitaran pada ubat berbentuk tablet. Dalam kajian ini, sampel didedahkan dengan keadaan dan pencemaran yang berbeza termasuk tertutup, suhu, air, asid, bes dan minyak. Kemudian, sampel tersebut didedahkan selama satu minggu dan satu bulan dalam keadaan yang ditetapkan. Setelah tamat tempoh pendedahan, pemeriksaan fizikal dilakukan untuk memeriksa perubahan fizikal yang berlaku pada tablet. Profil sampel telah dihasilkan melalui analisis spektroskopi inframerah transformasian Fourier (ATR-FTIR). Data ATR-FTIR juga dianalisis dengan Analisis Komponen Utama (PCA) untuk membezakan sampel tablet ubat berdasarkan pendedahan persekitaran. Walaupun didedahkan kepada faktor persekitaran, kesemua profil ATR-FTIR kelihatan sangat serupa antara sampel kerana parasetamol adalah ramuan utama tablet. Oleh sebab PCA tidak menunjukkan pembezaan bererti dengan pendedahan persekitaran yang berbeza, Analisis Diskriminasi (DA) telah dilakukan untuk mewujudkan visualisasi dan pembezaan yang lebih baik antara sampel dalam kumpulan. Keputusan dari DA menunjukan bahawa Panadol Kanak-kanak dan Panadol Larut telah mencapai 100% pemilikan kluster dengan betul. Tambahan pula, Panadol-650 telah mencapai 88.9% pengkelasan

yang tepat. Sampel lain termasuk Paracil (SM), Paracil (Mal), Panadol Menstrual, Uphamol-650 dan Febricol-RX sukar untuk dibezakan. Kesimpulannya, pemerhatian fizikal lebih sesuai dalam membezakan dadah berbentuk tablet berbanding dengan analisis kimia. Pendedahan luar dinampakkan tidak mengenakan sebarang kesan dalam ciri-ciri fizikal dan kimia dalam dadah-dadah yang diuji dalam kajian ini.

FORENSIC DETERMINATION OF DRUG TABLETS UPON EXTERNAL EXPOSURES

ABSTRACT

Pharmaceutical tablet is a prescription dosage type that includes the active componen t of the medication material with the suitable diluents. Exposure of drugs to environmental factors, such as moisture, heat and stress, might deteriorate the product as well as change the physicochemical properties of the drug. Such changes might also influence the safety and effectiveness of the medication tablet. This study was aimed to investigate the effect of environmental exposure on drug tablets. In this study, the samples were insulted with different condition and contaminants including closed, temperature, water, acid, base and oil. The samples were then exposed for the duration one week and one month. After the exposure duration end, physical examination was conducted to examine the physical changes that occur to the tablets. Samples profiles were generated through attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR) analysis. The ATR-FTIR data was also decomposed by Principal Component Analysis (PCA) to distinguish the drug tablet samples based on the environmental exposures. Although subjected to environmental exposures, the ATR-FTIR profiles appeared very similar among the samples, as paracetamol is the main ingredient of the tablet. Since PCA did not showed significant discrimination with different environmental exposure, Discrimination Analysis (DA) was conducted to create better visualization and differentiation among the samples. DA results demonstrated that Panadol for Children and Panadol Soluble had achieved 100% correctly clustering. Additionally, Panadol-650 had reached up to 88.9% accurate

classification. Other samples including Paracil (SM), Paracil (Mal), Panadol Menstrual, Uphamol-650 and Febricol-RX were hardly to be distinguished. In conclusion, physical observation was more suited in discrimination of tableted drug as compared to chemical analysis. External insults were found not to introduce any impact in the physical and chemical characteristics on the drugs tested in this study.

CHAPTER 1

INTRODUCTION

1.1. Drug Tablet

Drug tablet is a pharmaceutical dosage in solid form containing active ingredient of drug substance with appropriate diluents (Bhowmik, 2014; Lanjewar *et al.*, 2017). Drug tablet is usually produced by compression or moulding method. Compressed tablet is produced by large scale production method while moulded tablet is produced by small-scale operation. Tablets continue to be the most preferred dosage form because of the benefit the tablet give towards the manufacturer and patient. Tablet type drug provides better protection to the drug from external temperature, humidity, oxygen, light and stress during transportation. In addition, tablet also ensures accurate of dosage, compactness, portability, softness of taste and ease of use (Bhowmik, 2014).

Drug tablets can be divided into several types that are compressed, moulded or triturated, dispensing and hypodermic. Compressed tablet is formed by compression of powdered, crystalline or granular active material either alone or in combination with few excipients such as binders, disintegrate agents, sustained-release polymers, lubricants, diluents, flavourings and colourants (Bhowmik, 2014; Pharmapproach, 2017a). Compressed tablets can be in uncoated or coated form (Pharmapproach, 2017a). Moulded tablet is made from moist material using a mould that gives the shape of cut sections of a cylinder. Such tablet must be the types of completely and quickly

soluble. Dispensing tablet is a tablet that is intended to be added to a given volume of water in order to produce a solution for a given concentration of drugs (Bhowmik, 2014). Yet, this tablet is no longer in use due to its potential of being inadvertently distributed to the patient. Hypodermic tablet consists of one or more drugs with easily water-soluble ingredients; however, this drug is also no longer used due to the difficulty of achieving sterility (Pharmapproach, 2017a).

1.1.1 Tablet Preparation

As mentioned in previous section, drug tablets are made by compressing powdered drugs with different excipients using a tablet press. Several granulation methods have been used to produce a final powder blend in tablet, including direct compression method, wet granulation, and dry granulation or roller compaction (Jacques and Alexandridis, 2019; Techceuticals, 2015). The method was chosen on the basis of the ingredients possessing individual characteristics, such as flow properties and compressibility. The appropriate method requires a thorough investigation of each ingredient suggested in the tablet for a comprehensive approach (Bhowmik, 2014).

Direct compression is a process of compressing tablet directly from powdered material without altering the physical nature of the material. Generally, direct compression is selected for crystalline material with good physical properties such as flow property and compressibility (Bhowmik, 2014). The substances of the drug are ground and mixed with the excipients such as lubricants and disintegrate agents. Grinding and mixing are crucial processes, especially when the splitting tablets are produced using the direct blending process. Grinding can be used to size granules and facilitate a

homogenous mixture. If there is absence of granulation step, the appropriate excipients of comparable structure, morphology and particle size must be chosen. The uneven distribution of granule particle sizes and different granule shapes can lead to granule segregation within the compressed tablet (Jacques and Alexandridis, 2019).

Wet granulation is the most widely used method for tablet preparation because this method fulfils all requirements for a good tablet formation although it involves several steps and time-consuming. This method involves bounding the powder with a suitable binder by adhesion. The binder is diluted with the suitable solvent before being added to the blended powder to form wet granules, and then left to form dried granules. Surface tension and capillary pressure are important factors for the formation of the initial granules. Apart from that, the controlled processing parameter is also crucial which could affect the properties of the tablet as well as tablet partitioning (Bhowmik, 2014; Jacques and Alexandridis, 2019).

Dry granulation or roller compaction is used to form granules without using liquid solution. This method is used when the product is sensitive to moisture and cannot withstand high temperatures. Compacting and densifying powder is required when moisture cannot be used (Bhowmik, 2014). The coherent properties of the substance is important when roller compaction is applied. Roller compaction is used to release the air trapped and create dense compact material. Excipient with similar structure and comparable particle size should also be used to prevent segregation during compression of the tablet. Other than that, excipients with good compressibility factor such as plasticizer and binder concentration play important roles during this process

(Jacques and Alexandridis, 2019). Figure 1.1 illustrates the granulation method used in drug tablet preparation.

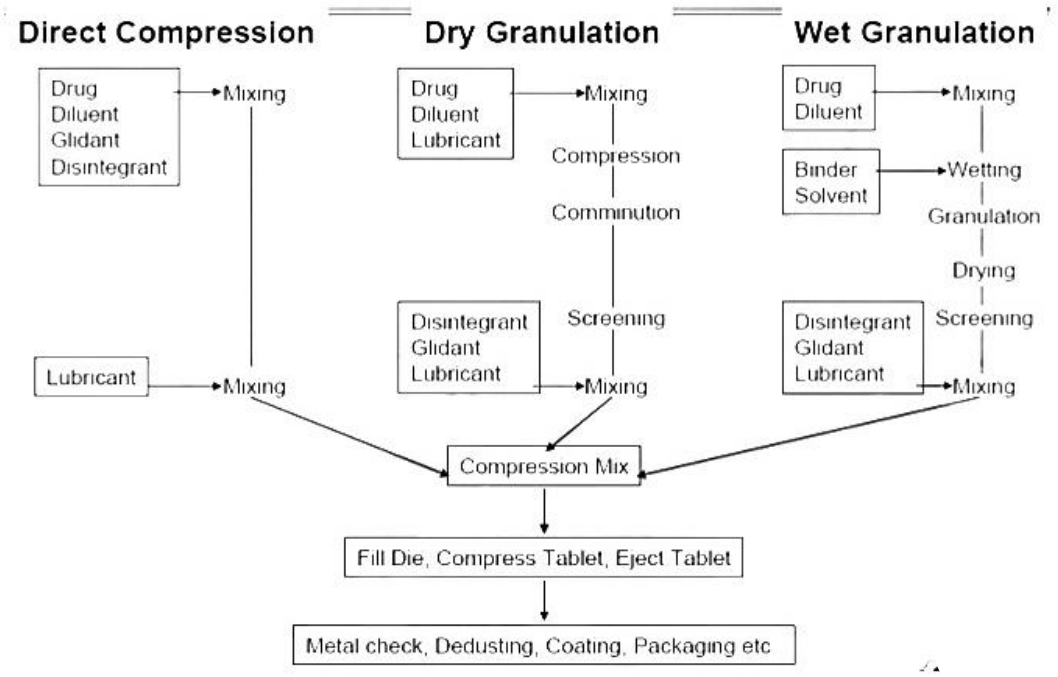

Figure 1.1: Granulation method used in drug tablet preparation (Nitin Kadam, 2010)

1.1.2 Tablet Ingredient

A drug in tablet form contains not only active substance but also various other materials known as excipients. Excipient is the additive substances used in the formulation of the tablet to enhance the durability, disintegration, bulkiness, dissolution rate and bioavailability of the drug (Chaudhari and Patil, 2012; Techceuticals, 2015; Varma, 2016). The formulator must carefully and critically evaluate the combination of the drug in order to ensure that there is no excipient interference with the utilisation of the drug. Excipients that are used in tablet formulation include diluent, binder or adhesive, disintegrate agent, lubricant, glidants,

colouring agent, flavouring agent and sweetener (Chan and Chew, 2002; Chaudhari and Patil, 2012; Varma, 2016).

Table 1.1: Purpose and example of excipient (Chan and Chew, 2002; Chaudhari and Patil, 2012; Varma, 2016).

Excipient	Purpose	Examples
Diluent	Filler that acts as a bulking agent or filling material of the drug when the drug dosage is insufficient to produce the volume	Sugars, lactose, sucrose, sorbitol, inorganic salts and polysaccharides i.e. primarily microcrystalline cellulose
Binder	Used as a binding agent, provides consistency and holds the powder together to form granules	Gelatin, glucose, lactose, cellulose derivatives, starch and Acacia
Disintegrate agent	Used to facilitate the disintegration or break down of a tablet when in contact with water in the gastrointestinal tract	Starch, clays, cellulose, cross-linked polymer and modified starch such as Primogel and Explotab
Lubricant	Used to reduce the friction between the die wall and tablet during compression and ejection of the tabletting process	Talc, stearic acid, magnesium stearate, calcium stearate, polyethylene glycol and paraffin
Glidants	Used to improve the flow of granules or mixture of powders by minimizing the friction between particles	Colloidal, silicon dioxide, Asbestos free starch, corn starch, fine silica, Magnesium stearate and purified talc
Colouring, flavouring and sweetening agents	Added to impart aesthetic appearance of drugs, provide product identification and improve the taste of chewable tablets	Natural pigments Synthetic dyes Spray dried and other flavors, syrups Mannitol, Saccharin

1.2 Problem Statement

Drug tablet must guaranteed for their reliable and reproducible quality during production and storage. Manufacturers are expected to test drugs during and after manufacturing to ensure the quality of the drug. With the achievement of desired quality, it could ensure the products are suitable for intended uses and not exposing the consumer to any risk. Although the drug had followed the standard requirement during manufacturing, the inability to keep them in good storage condition from manufacturing until dispensing to consumer may expose the drug to different external conditions. Even if so, the exposure of drug to the environmental condition such as humidity, heat and stress, or external chemical activity such as acid and base, may deteriorate the drug or change the physicochemical properties of the drug. Physicochemical properties of a drug is crucial to the stability, solubility, membrane permeability and drug affinity towards different tissue component in the body (Buba, 2016).

Besides, activities of smuggling and trafficking could also introduce extra pressure or insult to the drugs when transporting them from one place to another. Introduction of pressure and insult to the drug might deteriorate or change the safety and quality of the drug. The unsafety and poor quality of drug may cause varying effect to the users. Other than that, drugs collected from the crime scene must be carefully and properly handled and stored to prevent any changes or deterioration to the drug. Failure to handle and store the forensic evidence properly and appropriately may expose them to various external condition that may cause interference during the drug analysis. The interfered results may produce inconclusive result or inadmissibility of evidence to the use of court of law. Therefore, this study focuses on the determination of drug tablets

upon external exposure with the aim to gain information regarding the effect of drug tablets when exposed to varying exposure including temperature, water, acid, base, and oil contamination.

1.3 Aim and Objectives

The aim of this study is to determine drug tablets upon external exposures using Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) Spectroscopy. In order to achieve the aim, the objectives of this study are as follows:

1. To determine the physical features on the drug tablet packaging material by physical examination.
2. To investigate the effect of external environmental exposure towards the physical characteristics of drug tablets.
3. To analyse the chemical profiles of drug tablets upon external exposure using ATR-FTIR spectroscopy.

1.4 Significance of Study

The determination of drug tablets upon varying external exposure could provide important information to the investigators. Theoretically, exposure to the external condition such as temperature, water, acid, base and oil would affect the physical condition of the drug tablets as well as its stability and effectiveness. Other than that, exposure of the drug to the environment might have modified or deteriorate certain chemical composition of the drug, leading to possible interference during the drug analysis. Hence, the result might be inconclusive or not admissible to the court of law. Therefore, this study could provide better knowledge to the investigator when

handling, storing or transporting which could potentially exposed the forensic evidence to different external condition, and minimising the potential of further deterioration.

CHAPTER 2

LITERATURE REVIEW

2.0 Illicit Drug Problem

Illicit drug problem is always a global threat to the world population. According to the United Nation Office of Drugs and Crime (UNODC), the number of drug abusers aged 15 to 64 is estimated to have achieved 271 million people, at approximately 5.5% of the world population in 2017. The figure is expected to have increased in more recent years. In 2009, the prevalence of drug abusers was relatively lower at 4.8% and reaching approximately 5.5% as stated above. Although the prevalence of drug users was said to be stable for the past many years, its number had been increasing continuously as reflected by the global population growth (Vereinte Nationen and Büro für Drogenkontrolle und Verbrechensbekämpfung, 2019). Data showed higher prevalence use of opioid in countries such as Africa, Asia, Europe, North America, while the use of cannabis was highly reported in North America, South America and Asia regions. Over the past decade, there has been diversity of substances available in illicit drug market including plant-based substances and synthetic drugs. The expansion of potent drugs, non-medical prescription medicines and potential combinations of substance had causes greater and endless risk to the world (Vereinte Nationen and Büro für Drogenkontrolle und Verbrechensbekämpfung, 2019).

Drugs related crimes involve the manufacturing or cultivating, smuggling, trafficking, distribution, possession, sale, and lastly the abuse of illicit drugs. Before existing in the illicit drug markets, the active ingredients of these drugs are extracted from the

plant or synthesised from chemicals, and subsequently processed in the clandestine laboratories. They are frequently cut or adulterated with other substances before their distribution to the users to increase to sale bulk and to maximise the income. To reach to the users, these illegal drugs must be smuggled or trafficked through involuntary conveyance by means of carrying, mailing, making use of human or animals to carry, or by other means of transporting from one place to another. Upon reaching into a country or a targeted place, these drugs will be packaged, re-distributed and delivered to the drug abusers or criminals. In fact, the trading of illegal drugs frequently involves multiple layers of individuals throughout a series of activities (United Nations Office on Drugs and Crime, 1995).

Every act involving illicit drugs is always risky, complex and a serious security threat to the world population. Illicit drugs bring varying effects to the users, leading to behaviours which may generate violence and other illegal activities. Amongst, smuggling and trafficking drug is highly associated with violent crimes (United Nations Office on Drugs and Crime, 1995). Furthermore, drug users are more prone to commit crimes than non-users (U.S Department of Justice, 1994).

2.1 Smuggling and Trafficking Activities

Drug smuggling and trafficking are dangerous and risky activities by the criminal organisations that can corrupt public officials and destroy the structure of a country. Drug smuggling is not a business that can be compared with corporations or formal organisations. According to (Antonopoulos and Papanicolaou, 2008), drug smuggling is based on the formation of groups containing members known as 'officers' and individuals that help the business known as 'brokers'. Other than that, individuals who

involve actively in the smuggling and trafficking activity also include transporters and other specialised groups to support the business. In generally, the structure of drug smuggling organisations could have consisted of the office of transport, the office of finance, the office of distribution and the office of supply (Antonopoulos and Papanicolaou, 2008).

The tackle of illicit drug smuggling and trafficking activities by the law enforcement authorities is never ended and continue to be to more challenging. Moreover, such activities can be within the boundary of a country in smaller scale, but majority of them are transnational in nature. Both the parties, namely the drug syndicates and the law enforcement authorities, always compete with each other in which the former create ways of manufacturing, processing, smuggling, trafficking, distribution and sales to gain more profits while the latter implement more sophisticated procedure and detection techniques to counter the problems. Whenever there is a demand for illicit drugs by the users, the race between both these parties has no sign of ending.

The punishment imposed on individuals involved in drug smuggling and trafficking are different based on the countries. Drug smuggling and trafficking can be sentenced to death when caught in some countries, including China, Iran, Saudi Arabia, Vietnam, Malaysia, and Singapore. In United States, the penalties to drug smuggling and trafficking depend on the quantity of the substance and the number of offences that an individual have committed. The first trafficking offence could be punished with at least 5 years in prison. The sentenced could be increased to minimum 20 years if someone was injured during the smuggling and trafficking activity. However, if an individual

had committed a second offence that leads to serious injury, the individual shall be punished with mandatory life imprisonment (Patterson and Thomas, 2017).

Although harsh penalties and punishment had been implemented by the authorities, due to the possibility to obtain big money when succeed, the drug syndicates are deemed worth taking the risks. They find ways to escape the supervision and detection by the law enforcement authorities which can be generally divided into personal or impersonal activities. Personal smuggling and trafficking activities involve transportation of illicit drugs across the border or passed by the detection system in person. On the other hand, impersonal activities do not directly involve the drug traffickers. Additionally, the smuggling and trafficking activities are also varied according to different regions and countries due to the demands of illicit drugs and drug policies. All regions in the world had been severely impacted by the drug issues.

2.1.1 East and Southeast Asia

Drug problem in East and Southeast Asia is a serious issue especially when Afghanistan, Myanmar and Laos are the largest producers of illicit opium in the world. Besides, increase manufacturing of illicit amphetamine-type stimulants (ATS), especially methamphetamine in China and Myanmar has also caused a major concern to East and Southeast Asia (Kulsudjarit, 2004; United Nations Office on Drugs and Crime, 2018).

2.1.1.1 Methamphetamine

In the 2000s, there has been a huge transformation in the drug market from opiates to methamphetamine in East and Southeast Asia. The transformation to

methamphetamine had affected countries that were known to be a large market for heroin such as China and Malaysia. For the first time in Malaysia, the number of methamphetamine user has exceeded the heroin user in 2017 (United Nations Office on Drugs and Crime, 2019a).

East and Southeast Asia are the biggest manufacturers of illicit ATS, especially methamphetamine, in the world (Kulsudjarit, 2004; McKetin *et al*., 2008). All the 13 countries in East and Southeast Asia reported that methamphetamine is their main problem in 2018 (United Nations Office on Drugs and Crime, 2019a). Reported by United Nations Office on Drugs and Crime (2010), six countries compromises of Cambodia, China, Laos, Myanmar, Thailand, and Vietnam use tablet form methamphetamine while others use methamphetamine in crystal form (United Nations Office on Drugs and Crime, 2012, 2010). Methamphetamine has been supplied to the illicit market either through the local clandestine manufactured or trafficking for the past several decades (Shukla *et al*., 2012; United Nations Office on Drugs and Crime, 2019a).

In 2017, the biggest amount of methamphetamine seizure was reported from this region with more than 82 tons of methamphetamine were seized (United Nations Office on Drugs and Crime, 2019b). While in 2018, the methamphetamine seized had increased substantively reaching nearly 116 tons per year. The increase production of methamphetamine in East and Southeast Asia occur due to the decrease in the retail price of the drug. Besides, the precursor chemicals for methamphetamine had also frequently trafficked within the region (United Nations Office on Drugs and Crime, 2019a).

Both tablet and crystalline form of methamphetamine had continued to increase in East and Southeast Asia (United Nations Office on Drugs and Crime, 2019b). UNODC reported that seizure of methamphetamine tablet form had continued to increase annually. Nearly 450 million of methamphetamine tablets were seized in 2017, making up a 40% increase as compared to the previous year. In 2018, an estimated 745 million of methamphetamine tablets were seized in East and Southeast Asia (United Nations Office on Drugs and Crime, 2019b). From the data reported, more than 515 million of methamphetamine tablet were seized in Thailand and the amount seized is 17 times more than the combined amount of methamphetamine seized for 10 years by all countries in East and Southeast Asia. The surplus of methamphetamine tablets within this region might be because of the decrease in the retail price of methamphetamine in several countries, including Cambodia, Malaysia, Myanmar and Thailand (United Nations Office on Drugs and Crime, 2019a).

The seizure of crystalline form methamphetamine has increased every year over the last decade. In 2018, around 48 tons of crystalline methamphetamine was seized in East and Southeast Asia. Six Mekong countries consists of Cambodia, China, Laos, Myanmar, Thailand and Vietnam contributed a total of 72% of crystalline methamphetamine from seizure between 2013 and 2018 (United Nations Office on Drugs and Crime, 2019a). In 2017, Thailand reported that almost 91% of analysed samples has demonstrated up to 90% purity while China reported 89% purity level was detected in majority of seized samples. Other countries such as Brunei Darussalam, Cambodia, Indonesia, Malaysia and Vietnam reported high purities between 70% and 80% (United Nations Office on Drugs and Crime, 2019b).

Data on the seizure of methamphetamine by region in Thailand proposed significant changes in trafficking pattern of methamphetamine originated from Golden Triangle with increase flow of crystalline methamphetamine into Malaysia. In 2018, one-third of the entire drug seizure seized in Southern part of Thailand, near to Malaysia were crystalline methamphetamine (United Nations Office on Drugs and Crime, 2019a). In 2015, China and Hong Kong have become the top methamphetamine trafficked to Australia. While, in 2017, Thailand and Malaysia have respectively ranked second and third for methamphetamine trafficking after the United State (United Nations Office on Drugs and Crime, 2019b). Moreover, Laos has been used as the targeted transit point for methamphetamine trafficked within and from the regions of East and Southeast Asia. From 2016 to 2018, seizure of methamphetamine in tablet form had increased substantively 75% along the Laos and Thailand border with approximately 5.1 million to 21 million tablets (United Nations Office on Drugs and Crime, 2019a).

In 2018, large flows of methamphetamine tablets from Myanmar to Bangladesh were reported by the Government of Myanmar with approximately one-third of the drug seized in the country. Currently, there have been large scale trafficking of methamphetamine in the maritime domain that included Indonesia, Japan, and Australia. More than 2.6 tons of crystalline methamphetamine were seized in Riau Island of Indonesia. Most drug dealer arrested were Taiwanese people. Over the last two decade, Taiwanese people were arrested for methamphetamine trafficking to countries such as Australia, Cambodia, Japan, Malaysia, Philippines, Korea and Thailand (United Nations Office on Drugs and Crime, 2019a).

Apart from trafficking within the East and Southeast Asia, drug trafficking activities outside this region was also on the rise. There has been evidence where methamphetamine has been trafficked to Israel from the Mekong region. Methamphetamine trafficked to Israel from Laos, Thailand and Vietnam were recorded as ten top trafficking routes of methamphetamine in Asia and Pacific in 2017. Japan and Korea also reported trafficking of methamphetamine from the outside region such as North America and Mexico. Estimated 27 parcel posts containing crystalline methamphetamine were seized with 26 of these parcels have been sent from California during the first half of 2018 (United Nations Office on Drugs and Crime, 2019a).

Other than the drug itself, the chemical precursor to produce methamphetamine had also been detected to be trafficked into the country. In recent years, seizure of chemicals such as tert-butyl methyl (1-phenylpropan-2-yl) carbamate (t-BOC) has been seized in Australia, Japan, and New Zealand. t-BOC is easily to be converted to methamphetamine by treating with sulphuric acid. Besides, ephedrine and pseudoephedrine remain as the main chemical precursors to produce methamphetamine in China, Australia, and Korea. Nevertheless, there has been a clear indication of the extensive use of 1-phenyl-2-propanone to produce methamphetamine in Golden Triangle countries. Again, Laos is a targeted transit point for smuggling of chemicals used to manufacture methamphetamine with 5 tons of chemicals was seized reported in 2018 (United Nations Office on Drugs and Crime, 2019a).

In 2017, 206 tons of 2-bromo-1-phenyl-1-propane has been seized by the Chinese authorities. 2-bromo-1-phenyl-1-propane is a chemical that is not under international control but still can be used to manufacture illicit ephedrine. As a result, the smuggling

for chemical precursor has become challenging to the country. Besides, sodium cyanide which is not listed under international control can also be used to manufacture methamphetamine. A huge quantity of sodium cyanide has been seized in Myanmar and Thailand since 2016. Still, there is no proof on the utilisation of this chemical compound to manufacture methamphetamine in Golden Triangle countries (United Nations Office on Drugs and Crime, 2019a).

2.1.1.2 Heroin

Even though heroin is produced in about 50 countries worldwide, Southwest Asia, Southeast Asia and South America are the main regions of illicit poppy cultivation (NicDaéid and McKenzie, 2019). Myanmar has become the main producer of opium, heroin, and amphetamine-type stimulants (ATS) after Afghanistan. Note that Afghanistan is the world largest producer of illicit heroin in Asia (Reid *et al*., 2006). Yong-an (2012) stated that 90% of global illicit opium was produced in Afghanistan and Myanmar (Yong-an, 2012). The reported percentage showed that the global opiates market has never been eliminated or decreased significantly since 1998 (United Nations Office on Drugs and Crime, 2019c). However, there had been a reduced amount of opium produced in Myanmar, dropped for approximately 40% from 2013 to 2018 (United Nations Office on Drugs and Crime, 2019a). This could be due to the increase dismantle of heroin clandestine laboratories and seizures of large amount of illicit heroin by law enforcement authorities in the past decade (Reid *et al*., 2006).

The Myanmar-Yunnan-Guangdong route is the most route used to traffic drug into Southern China. However, due to the increased law enforcement efforts at the China-Myanmar border, the China-Vietnam border had increasingly being used as the route

for drug trafficking (Yong-an, 2012). Other than that, an increase of illicit smuggling and trafficking of heroin into East and Southeast Asia could also be due to Malaysia which had been used as the transit hub to distribute this illicit drug to other Asia countries. The border between Thailand and Malaysia in the northern region is the possible entry routes used by drug traffickers (Yusoff *et al*., 2020).

Data from World Customs Organisations revealed that an estimated 70% of heroin seizure in China was produced from Myanmar (Yong-an, 2012). While, the World Drug Report reported that 11% of the total global quantities of heroin and morphine were seized in East and Southeast Asia, excluding the seizure in Afghanistan (United Nations Office on Drugs and Crime, 2019c). The total seizure of heroin in Myanmar, Thailand and Vietnam had increased as in 2018. Vietnam is the country with the major seizure of heroin reported with one third of all illicit heroin seized in East and Southeast Asia from 2013 to 2018. Malaysia has also been reported with an increasing seizure of heroin being trafficked to this country as an route to the Australia (International Narcotics Control Board, 2019a).

2.1.1.3 New Psychoactive Substance (NPS)

Over a decade, a total of 434 different NPS was seized in East and Southeast Asia. In East and Southeast Asia, the most identified NPS is the synthetic cannabinoids followed by synthetic cathinones and phenethylamines. Synthetic cannabinoids are not only commonly trafficked in East and Southeast Asia but also had contributed the largest globally. Japan and Korea were reported with the largest proportion of synthetic cannabinoids in East and Southeast Asia region followed by Vietnam and Indonesia (United Nations Office on Drugs and Crime, 2019a).

Between 2013 and 2018, the seizure of synthetic opioids in East and Southeast Asia have risen from three to 19 substances. Overdose consumption of synthetic opioids had caused deaths to the outside regions such as North America, Japan, and China. However, there is a lack of information regarding the seizure of synthetic opioids. This could be due to the substitution of heroin with synthetic opioids or adulteration of heroin with synthetic opioids to increase their profit (United Nations Office on Drugs and Crime, 2019a).

Psychoactive plants including kratom and khat seizures were reported in East and Southeast Asia. These plants had been used on the local people, particularly in South East Asia for centuries, but they have recently been severely abused. Seizure of kratom plants was common in countries such as Malaysia, Myanmar, and Thailand. While, khat plant was reported in countries such as Cambodia, Hong Kong, China, Korea and Vietnam for the past two years (United Nations Office on Drugs and Crime, 2019a).

Seizure of ketamine has been reduced since 2015 due to a decrease in the quantity of ketamine seizure in China. Seizure of ketamine in China decreased for more than 60% from 19.7 tons to 7.3 tons and 40% decrease in clandestine ketamine laboratories from 97 to 54 between the year 2015 and 2017. However, the seizures of ketamine in Cambodia, Malaysia, Myanmar, and Thailand continue to increase in recent years. Manufacturing and trafficking cases of ketamine showed that Indian drug trafficking syndicates might have played the role in ketamine market in East and Southeast Asia. In June 2017, Indian authorities seized 110 kg of ketamine and 55.5 kg of

pseudoephedrine in Chennai, India where the illicit drug was about to traffic to Malaysia (United Nations Office on Drugs and Crime, 2019a).

2.1.1.4 Ecstasy

Smuggling and trafficking of ecstasy remain insignificant as compared to methamphetamine. Approximately 9 million ecstasy tablets were seized in East and Southeast Asia in 2017. Countries such as Brunei Darussalam, Indonesia, Malaysia, and Singapore have recorded an increment in usage of ecstasy tablets (United Nations Office on Drugs and Crime, 2019a). However, it was noted that there is no country in East and Southeast Asia reported ecstasy as the top three most abused drugs, except Indonesia. Between 2013 and 2017, Indonesia has recorded an increase in the seizure of ecstasy with 40% followed by China 28% and Malaysia 14%. A case of trafficking 1.2 million ecstasy tablets from the Netherlands was reported and seized in Indonesia (United Nations Office on Drugs and Crime, 2019b). In August 2018, 98 kg of ecstasy was seized by Cambodia authorities. This seizure was reported to the largest amount ever seized by the country. Philippines authorities also reported in seizing 14,720 ecstasy tablets trafficked from France in 2017 (United Nations Office on Drugs and Crime, 2019a).

The manufacture of ecstasy is not spread widely in East and Southeast Asia. Still, there are three countries including China, Malaysia, and Vietnam reported to have seized a number of ecstasy manufacturing facilities in 2017 (United Nations Office on Drugs and Crime, 2019b). During the seized of ecstasy manufacture facilities, Vietnam authorities reported in seizing 400 kg of ecstasy tablets, 85 kg of ecstasy powder and some amount of chemical precursor to manufacture ecstasy known as “safrole”.

Content of methylenedioxy-methylamphetamine in ecstasy tablets varies within different countries. After all, Cambodia and Indonesia reported that nearly 50% methylenedioxy-methylamphetamine was used in the ecstasy tablets (United Nations Office on Drugs and Crime, 2019a).

2.1.2 South Asia

Trafficking of the drug in South Asia also had grown rapidly throughout the region, especially in the border areas of the sub-region. Among the drugs trafficked to South Asia are heroin, cannabis, methamphetamine, as well as pharmaceutical preparations containing narcotics and psychotropic substances. The trends of trafficking drugs showed that synthetic drugs are currently substituting or replacing natural and semi-synthetic drugs (International Narcotics Control Board, 2019a). Moreover, the drug trafficking issue in South Asia had become challenging as there were one main drug producer and trafficker in the region, namely the Afghanistan. Besides, the coastal States of South Asia have a higher tendency to transport drug trafficking through maritime as they are exposed to trafficking routes across the India Ocean (International Narcotics Control Board, 2019a).

2.1.2.1 Cannabis

Cultivation of cannabis has become very challenging to law enforcement agencies in South Asia, especially India. Data from 2010 to 2017 showed that India was one of the countries that largely cultivated cannabis and produced cannabis. In 2018, Indian drug enforcement authorities had seized 1,980 hectors of illicit cannabis cultivation which was considerably less than 2017, reported at 3,446 hectors. While in Sri Lanka, an estimated 500 hectors of cannabis cultivation were seized in 2018. In 2017, 100,000

cannabis plants taken from 12 cultivation have been destroyed in Bhutan (International Narcotics Control Board, 2019a).

The total of cannabis herb seized in 2018 had decreased to 336 tons as compared to the previous year with 434 tons. The largest quantities of cannabis herb seized in South Asia was in India with 266.5 tons or 79% of the total seizure, followed by Bangladesh with 60.3 tons or 18% of the total seizure. Other countries such as Bhutan, Nepal, and Sri Lanka reported with approximately 3% seizure amounted 9.1 tons. Seizure of cannabis resin in South Asia had increased from 3.2 tons in 2017 to 5.2 tons in 2018. The major countries that seized 100% or 5.2 tons of the cannabis resin were India and Nepal (International Narcotics Control Board, 2019a).

2.1.3.2 Heroin

Eradication of illicit opium poppy has increased over the four consecutive years since 2015 in India. In 2018, 16 tons of poppy straw was seized in India, 70% greater than the total amount of poppy straw seized in 2017. Opium seizure in India had also increased with 1.7 tons, 2.3 tons, 2.6 tons and 4.1 tons between 2015 and 2018, respectively. The data seizure of opium and poppy straw showed that the problem of illicit opiates in South Asia was severe, affecting the general population (International Narcotics Control Board, 2019a).

Seizure of heroin had increased in South Asia, especially Sri Lanka due to the expanding use of the southern route for trafficking drug. Majority of the heroin trafficked to South Asia crossed from Afghanistan to Pakistan and then to South Asia. Since that, the seizure of illicit heroin in Sri Lanka had continued to increase rapidly

to 732 kg in 2018 as compared to the previous year with 315 kg. However, it was noted that the seizure of heroin in South Asia had declined to 2.4 tons in 2018 from 2.9 tons in 2017. Countries that seized illicit heroin the most in South Asia was India with 1.2 tons followed by Sri Lanka and Bangladesh with 0.7 tons and 0.45 tons, respectively (International Narcotics Control Board, 2019a).

2.1.3.3 Methamphetamine

South Asia is targeted by the Myanmar transnational organised criminal groups to the produce and traffic methamphetamine in South Asia. Methamphetamine is one of the abused drugs among the ATS in South Asia. Seizure of methamphetamine in South Asia was estimated to be 1% of the total seizure of methamphetamine at the global level. Methamphetamine seizure in Bangladesh continued to increase with an amount of 53 million tablets in 2018 and 40 million tablets in 2017. The increase was probably due to the nationwide anti-drug operation conducted by the Government. Besides, 147.83 kg of methamphetamine were seized in the first quarter of 2019 (International Narcotics Control Board, 2019a).

2.1.3 Africa

Africa continues to encounter various challenges poses on drug trafficking and drug abuse. Sahel countries such as Mali, Mauritania and Niger showed an increasing volatility and insecurity due to increased drug trafficking from the south regions to the north region, mainly Libya (Shaw and Reitano, 2013). In the recent one quarter of a century, drug trafficking had been developed across Africa countries, especially Nigeria which acts as an intermediary for this illegal activity (Dorn et al., 2005). Data seizure in West Africa countries showed that these countries remain as the main transit