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Current situation of pesticide consumption and poisoning in Saudi Arabia

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Abstract
Quality and safety about food received increased attention nationally and internationally. The growing use of pesticides accounts for a significant portion of the increase in food productivity over the past several decades. We conducted a retrospective descriptive review of all the reports and cases from 1990 onwards till date, if available. The data regarding pesticide consumption in Saudi Arabia are freely available and also we tried to go through the reports available on Google, PubMed, FAOSTAT, WHO, ESCWA if available. This study was conducted using these reports to critically gather all of the information from the reliable sources with the aim of presenting the descriptive review on pesticide consumption in Saudi Arabia. The consumption and use of pesticide increased steadily from 1996-2013. It was observed that in 2013, the total insecticide usage was 3130.5 tonnes of active ingredients when compared with year 2012 (2889 tonnes of active ingredients). Organophosphate ranked first among other pesticide consumption. A consistent training about the use and safety procedures of pesticide should be given to farmers, retailers, distributors and all the pesticide workers. Multimedia awareness activities in the common language should be massively conducted.

Keywords: Knowledge, Pesticide, Poisoning, Saudi Arabia

Introduction

1.1 Background

Man has developed different measures and methods to control the invertebrates, vertebrates and microorganisms that have always posed threat to the supply of food and also to the health. From the time of Homer (1000 B.C.) the historians have traced the use of pesticides. The most primitive record of insecticides refer to the burning of "brimstone" (sulfur) as a fumigant. In natural history Pliny the Elder (A.D. 23-79) recorded most of the earlier insecticide usages [1, 2]. In the 16th century, Chinese employed moderate amounts of arsenical compounds as insecticides and after hundred years, the first natural insecticide – 'Nicotine', was used against the plum curculio and lace bug [2, 3]. Subsequently, in the year 1828, a second natural insecticide, 'Pyrethrum' was introduced to combat various pests. By the middle of the 19th century the first scientific and systematic studies commenced and soap was added to the list of insecticides to kill aphids [2, 3]. The range of materials used for pest control widened, but the materials remained of simple chemical composition. In 1867, an impure copper arsenite called 'Paris Green' was used to check the serious spread of the Colorado beetle. Bordeaux mixture, comprising copper sulphate, lime and water, introduced in the year 1885 is still being used as one of the most important fungicides [1].

The use of pesticides accelerated between the years 1920-1940, and the number and complexity of the materials employed increased simultaneously. At the beginning of World War II (1940), the insecticide selection was limited to several arsenicals, petroleum oils, nicotine, pyrethrum, rotenone, sulfur, hydrogen cyanide gas, and cryolite. By the end of the war, there was a rapid development in the agrochemical fields, with the plethora of insecticides, fungicides, herbicides and other chemicals become in use. The discovery of the insecticidal properties of DDT and organ phosphorous compounds (OP) were the notable advances during the world war which opened the 'Modern Era of Chemical Control' with the introduction of synthetic organic insecticides[1,2,3].

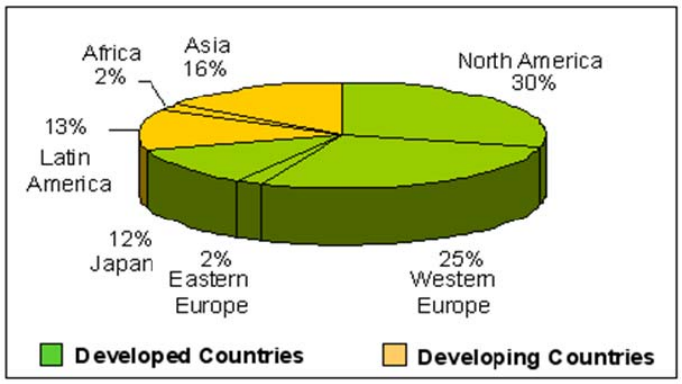
1.2 Objective

Health education, knowledge about pesticides usage to the farmers is an important step to eradicate the pesticide poisoning. Therefore, an integrative literature scrutiny was undertaken in order to do retrospective reviews from all the reports of pesticide consumption and poisoning available till date.

1.3 Global use of Pesticides

For mankind, the advancement and use of insecticides have produced immense benefits as they kill unwanted pests by disruption of their vital processes through chemical action. Therefore, they are the main contributors for the boost in agricultural productivity over the past three decades. The use has resulted in foodstuffs of the utmost quality and also has saved millions of lives through obliteration of disease-carrying insects.

Pesticides provide immediate effective control at a practical cost. With time, the sale of pesticides is increasing globally. In the developed countries, the use of crop protecting chemicals has played a major role in the increased and efficient production of food. At present, the developed countries are using more pesticides to control wide varieties of pests compared to the developing countries (Figure 1). In the developed countries, the use of crop protecting chemicals has played a major role in the increased and efficient production of food. The major classes of pesticide based on their use/action are listed in Table 1.



Source: "Upturn in World Agrochemical Sales in 1994, "AGRO: World Crop Protection News No. 238 (August 1995), p.20.

Fig 1: Use of pesticides in developed and developing countries.

1.4 Classification of Insecticides

Insecticides are classified on the basis of chemical nature, mode of entry and mode of action.

1.4.1 Classification based on chemical nature*:* Insecticides are classified based on the chemical nature as follows:

1. Inorganic compounds: arsenicals, fluorine compounds.
2. Organochlorines: DDT, BHC, carbaryl, phorate
3. Organophosphates: malathione, parathione
4. Pyrethroids: Permethrin, cypermethrin, deltamethrin
5. Botanicals: Nicotine sulphate, pyrethrum

1.4.2 Classification based on mode of entry

1. **Stomach Insecticides:** The insecticides are applied to that part of the crop, which serves as food for the pest and is required in the normal process of eating. Their application is through food and entry through the midgut of the insect. Stomach poisons are necessarily to be ingested to cause insecticidal action. Examples: DDT and BHC.
2. **Contact poisons:** Contact poisons are those, which kill the pest only due to contact or absorbed action. Their application is through the body surface and entry through the cuticle and tracheae. Examples: pyrethrum, rotenone, toxaphene and chlorodane.
3. **Fumigants:** Gaseous poisons used for killing insects are called fumigants. These are applied in vapour state and their entry is through tracheae. Examples: HCN (hydrogen cynide), chloropicrin, methyl bromide and aluminium phosphide.
4. **Systemic insecticides:** Systemic insecticides are toxicants which when applied to the root, stem or leaves of plants are rapidly absorbed through xylem vessels and translocated to various parts of the plants in amounts lethal to insects feeding on them. Examples: phorate, aldicarb and carbofuran.

1.4.3 Classification based on mode of action

1. **Physical poisons:** These compounds exert a physical rather than a biochemical effect and actually kill the insects by suffocation.
2. **Inert dusts:** They effect a loss of body moisture from insects by two types of action. Abrasive dusts e.g. aluminum oxide cause water loss by lacerating the epicuticle and water adsorbents, For Example: charcoal removes water as a consequence of their hygroscopic properties.
3. **Heavy mineral oils:** These may exert a purely asphyxiate effect killing scale insects slowly by exclusion of air.
4. **Protoplasmic poisons:** The action of these poisons appears to be associated primarily with the precipitation of proteins. Examples: heavy metals, nitrophenos and nitro-cresols.
5. **Respiratory poisons:** They combine with cytochrome oxidase and other oxidases containing iron and thus inhibit their catalytic action. Examples: HCN, H2S and CO.
6. **Nerve poisons:** The action of these poisons in associated primarily with their solubility in the tissue lipids. Examples: chlorinated hydrocarbons, organophosphates, and botanical insecticides.

1.5 Pesticide use in gulf countries

There is paucity and gap in providing the data on the usage of pesticides in the gulf countries given that fewer than half of the ESCWA[4] member countries provided the data for 2000, and only two countries Bahrain and Syria provided data for 2001 (Table 3). In Figure 2, the rate of pesticides usage per hectare in Lebanon, Kuwait and Qatar are 2 to 3 times the rates used in Egypt, Jordan and Oman. Farmers should use these chemicals only when required and in moderate amount to avoid sending to the market low quality products, especially fruits and vegetables which are consumed fresh. At present, the developed countries are using more pesticides to control wide varieties of pests compared to the developing countries [5].

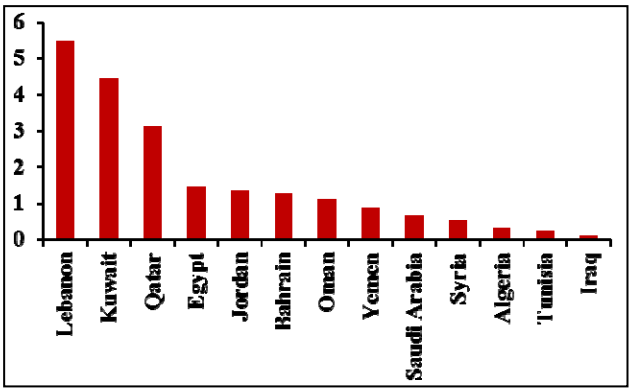


Fig 2: Amount of pesticide used in Kg/Ha in some Arab countries

1.6 Organochlorine pesticides residues in various food products of Saudi Arabia

Use a varied range of chemicals to destroy pests and weeds is a significant aspect of agricultural practice globally. Certainly,

this has increased crop yield and reduced postharvest losses. However, the prolonged use of such pesticides expectedly results in residues in foods, which has led to widespread concern over the potential adverse effects of these chemicals on human health. Approximately 1400 pesticides are in use worldwide. Commonly used pesticides include herbicides (destroys unwanted weeds and plants), insecticides (kills insects and other arthropods), rodenticide (controls mice and other rodents), and fungicides (kills fungi) [6]. All pesticides are toxic by their nature, and hence, they cause health hazards to human and animal through exposure or dietary intake. Table 4 in this review found an evidence of OCPs in Saudi Arabia.

1.7 Pesticide consumption in Saudi Arabia

Pesticide consumption has been increased rapidly in Saudi Arabia for increased development in agriculture. It is estimated that the total quantity of pesticides imported to Saudi Arabia was 46 million Saudi Riyals (U.S. $12,267 million) in 1976 when compared to 331,400 million Saudi Riyals (U.S. $88,373 million) in 1990. In 1976 the estimated number of tons was 4,999 which was increased to more than 20,000 tons in 1990. In this study we have found that from year 1996 there was a steady increase in the consumption/use of pesticide (Figure 3 and Table 5).

In 2008-2009 the kingdom imported 2.15 million liters, 0.590 tons of powder form pesticides, as well as 360 thousand liters, and 613 tons of powder fungicides, and 1.8 million liters, and 145 tons of powder herbicide for all purposes. (Hijri 1429/1430) (Ministry of Agriculture, 1431). It is important to know whether these quantities were used properly according to the safety procedures mandatory for the innocuous application of pesticides. It's a serious issue and needs attention.

In 2013, the total insecticide usage was 3130.5 tonnes of active ingredients when compared with year 2012 (2889 tonnes of active ingredients) (Figure 3). In 2007, the consumption of OP pesticides was high (1787 tonnes of active ingredients) when compared with the year 1996 and 1997. Among others, Carbamates were most commonly used after OP (426.7 tonnes of active ingredients) when compared with the year 1996 and 1997 (48 and 87 tonnes of active ingredients respectively) (Table 4). Among all pesticides rodenticides were less often used in the year 2007. On the other hand, the use of herbicides was reduced from 2007 (734.8 tonnes of active ingredients) to 190.7 tonnes of active ingredients in 2012. In 2013, the range was not high as was in 2007.

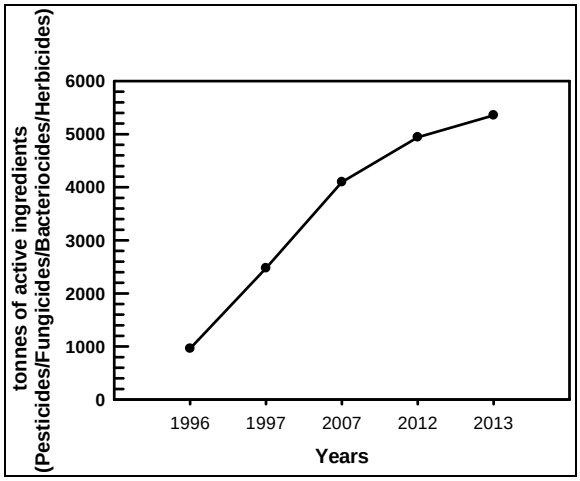


Fig 3: Trend in increase of pesticides consumption in Saudi Arabia.

1.8 Pesticide poisoning in Saudi Arabia

The frequency of organophosphate poisoning has increased in recent years in Saudi Arabia. This is in accordance with the findings of other studies, in which, OP compounds were the most repeatedly involved in both accidental and occupational poisonings [7-11]. Jumaan *et al*., (2015) [12] showed that from a total of 50 patients of OP poisoning: Thirty-four males (68%) and 16 females (32%), 39(78%) of whom were >18 years of age. Ingestion was the most common route of exposure which was observed in 20 patients and two patients had cardiac arrest. The majority of suicidal attempts were males at 77%. The study also revealed that the 20-30 age groups were significantly more prone to suicide than other age groups.

In the Qassim region of Saudi Arabia the cases of acute chemical poisoning reported to the preventive medicine department from 1999 to 2003 increased from 66 to 114 during the study period [7]. Mean age of patients were 17.7 years, and over 39% were children aged < or = 5 years. Pesticides were the most common chemical involved; paracetamol and other analgesics were also frequently reported. The oral route was the most frequent, while vomiting was the commonest symptom. Nine deaths were recorded, of which 4 were due to pesticide poisoning.

13 products have been published by daily Al-Watan possibly being sold in the Kingdom which may contain aluminum phosphide. This compound assumed to have caused death of a six year- old girl and a three-year-old boy. Pesticides that contain aluminum phosphide are only to be used by skilled professionals at crop transport, storage or processing facilities. The pesticide is useful under those restricted-use conditions because while the gas is toxic it leaves no residue on foodstuffs, such as grain. (Arab news)

The products listed by Al-Watan are: Agriphos, Alfox, Cellophos 75, Celphos, Fumiphos, Hiphos, Masaphos, Quickphos, Phosfume, Phostoxin, Premaphos, Shenphos and Synfume.

The Saudi Press Agency (SPA) published a list of restricted chemicals that was sent to pesticide companies were included in the circular sent to pesticide companies. The restricted chemicals reported in the local Arabic press were: bromadiolone, carbofuran (in liquid form), chlorpyrifos, ethoprophos, carbaryl, chlorothalonil, demeton-s-methyl, diclofop- methyl, dicofol, dimethoate, benomyl, mancozeb, endosulfan, tetradifon, zineb, methomyl, propargite, propoxur, quintozene,

imazine, methiocarb, methoxychlor and oxydemethel-methyl. (http://www.arabnews.com/node/321444) [13]

Table 1: Major classes of pesticide according to their use/action.

Type	Use / Action	Important examples
Insecticides	Substances that prevent, destroy kill mitigate insects (belonging to class insects, phylum arthropod).	DDT, malathione, deltamethrin
Fungicides	Substances that prevent, destroy or inhibit the growth of fungi/diseases in crops	Ampropylfos, carboxin
Herbicides	Substances which are used for preventing or inhibiting growth of plants or for killing weeds.	Acetochlor, 2,4-D and 2,4,5-T
Rodenticides	Substances that inhibit growth, destroy or kill rodents (Class Mammalia, order Rodentia)	Warfarin, arsenous oxide
Nematicides	Substances that prevent, destroy, repel or inhibit the nematodes.	Aldicarb, carbofuran
Chemosterilants	Substances that sterilize the pests.	Apholate, methiotepa
Molluscicides	Substances that prevent, repel, destroy or inhibit the growth of the Phylum Mollusca	Fentin, Copper sulphate
Plant growth regulators	Substance that cause the acceleration or retardation of the rate of growth or rate maturation	Acibenzolar probenazole
Defoliants	Substances that cause the plant leaves to die and fall away	Agent Orange
Desiccants	Substances that cause to drain moisture out of the plants causing them to dry.	Borates, Silica gel

Table 2: Some important insecticides and their actions

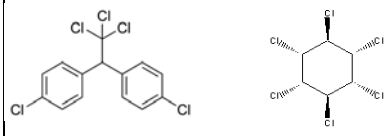
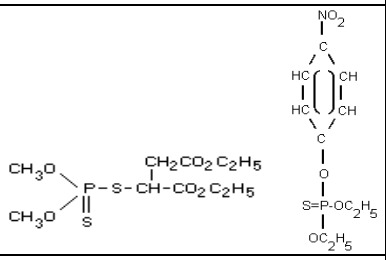
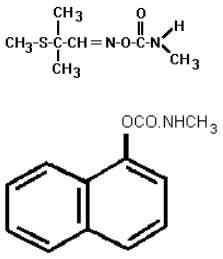
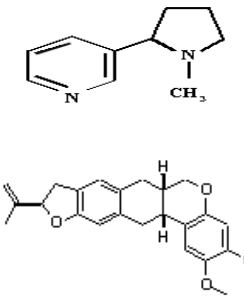
Groups	Name	Structure	Mode of Action
Organochlorines	DDT (1,1,1,-trichloro,2,2-di(p-chlorophenyl) ethane) Lindane (γ-benzene heacchlorohexane)		Nervous impairment indicated by hyper- excitability followed by ataxia (Dale *et al*., 1965). Increase in Ache level, excessive electrical activity in poisoned axons (Laolonde and Brown, 1954).
Organophosphates	Malathione Parathione		Inhibition of acetylcholinesestrase (Matsumra, 1975) Inhibition of acetylcholinesestrase (Matsumra, 1975)
Carbamates	Aldicarb Carbaryl		Cholinesterase inhibitor (Liddle *et al*., 1979). Potent contact and respiratory poison and is very efficient against chewing pest. (Liddle *et al*., 1979).
Botanicals	Nicotine Rotenone		Binds on to acetylcholinesestrase, receptors in the neuromuscular junction of mammals but in synaptic ganglia of insects, mimics acetylcholine (Flattum and Sternburg, 1970). Slow paralysis inhibits electron transport in mitochondria and this indirectly leads to in blocking of nerve conduction (Flattum and Sternburg, 1970).

Table 3: Total insecticides consumption in tons per year

Country	Years	
	2000	**2001**
Bahrain	7.0	6.0
Iraq	190	------
Jordan	61	------
Oman	91	------
Qatar	60	------
Syria	1,219	994
Yemen	933	------

Source: ESCWA, Compendium of Environment Statistics in the ESCWA region, 2007.

Table 4: Organochlorine pesticides residue in food and vegetables of Saudi Arabia.

Pesticide	Province	Food Type	Sample	Author	Results of the study
Amitrole, Anzobenzene, Bioallethrin, Biphenyl, Bromoxynil, Carbaryl, Carbofuran, Chloypyrifos, Dicofol, Dieldrin, ENT 92, Ethiofencarb, Heptenophos, Lindane, Malathion, Metalaxyl, Methoxychlor, Paraquat, Propoxur, Pyrethrin 1, Tolchflos – methyl, Warfarin	Al-Qassim	Different vegetables	160	Osman *et al*., 2010	Highest concentration were found in lettuce, followed by tomato, cabbage, carrot (3.3 mg/kg heptanophos), green pepper (2.23 mg/kg carbaryl) and eggplant (1.91 mg/kg of carbaryl).
Dieldrin, Lindane, Chlorpyrifos, Dimenthoate, Abamectin, Tourk, Dicol, Amitraz, Carbendazim, Benomyl, Altrazine, Glyphoshrinate, Deltamethrin, Cypermet	Riyadh	Dates	3 cultivars	El Saeid *et al*., 2010	0.07, 0.099 and 0.125 ppm of Dimethoate was detected on three date cultivars.
DDT, HCH, Methoxychlor, Hepatachlor epixode, Dieldrin, endrin, Endosulfan, Lindane	Qatif, Dammam, Al-Ahsa	Chicken fat	5 broiler farms and 10 chicken pluck shops	Homeida *et al*., 2008	The concentrations were below the level of maximum limits for fat tissues according to the European regulations, 1986.

Table 5: Consumption of pesticide in Saudi Arabia from 1996-2013.

Years	1996	1997	2007	2012	2013
1. Insecticides + (Total)	432	1073	2529.630	2889.700	3130.500
• Chlorinated Hydrocarbons	42	15	53.010		
• Organo-Phosphates	320	617	1787.730		
• Carbamates Insecticides	48	87	426.750		
• Pyrethroids	9	45	111.870		
• Botanic. Produc & Biologic.	0	0	41.120		
• Other Insecticides	13	309	109.150		
2. Herbicides + (Total)	348	951	734.840	190.700	206.500
• Phenoxy Hormone Products	55	150	12.210		
• Triazines	14	7	33.650		
• Carbamates Herbicides			127.870		
• Dinitroanilines	43	74	105.270		
• Urea derivates	15	183	10.980		
• Sulfonyl Ureas	79		5.860		
• Bipiridils			3.600		
• Other Herbicides	141	536	435.400		
3. Fungicides & Bactericides + (Total)	181	452	798.080	1856.400	2011.200
• Inorganics	19	20	130.410		
• Dithiocarbamates	89	122	51.070		
• Benzimidazoles	42	213	330.440		
• Triazoles, Diazoles	11	30	186.450		
• Diazines, Morpholines	6		.390		
• Other Fungicides	14	67	99.320		
4. Rodenticides + (Total)	0		35.070		
• Other Rodenticides	0		35.070		
5. Other Pesticides nes + (Total)	-			7.100	7.700
Unit: tonnes of active ingredients					

2. Conclusion

Arab countries face profound sustainability challenges that will influence their ability to achieve lasting environmental goals. Pesticides, when used in higher quantities than needed, become contaminants to food, feed and environment. However, when used properly, they will improve crop yield and quality. In the Arab countries the misuse of pesticides and fertilizers is common and thus a subject that should be given sufficient magnitude and consideration. Pesticides are used for pest management and vector control in agricultural areas, but many agricultural communities are not effectively informed about the hazards associated with the chemicals. Despite efforts to modernize food safety laws, there is limited information available to fully evaluate the food safety problems and issues. In Saudi Arabia, regulations for the registration and import of pesticides have been established and a large number of pesticides have been banned. Public awareness can be increased by more appropriate education programs based on pesticide control should be initiated at national level.

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