ISSN: 2639-4391

Annals of Epidemiology & Public Health

Open Access | Research Article

Pesticides contamination and nervous disorders in an agricultural area in Akkar, Lebanon. A cross-sectional study

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Received: Dec 24, 2019

Accepted: Feb 11, 2020

Published Online: Feb 13, 2020

Journal: Annals of Epidemiology and Public health

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/

Keywords: Alzheimer; Parkinson; Prevalence; Pesticides contamination; Groundwater

Abstract

Objective: Published studies in the second largest agricultural zone in Lebanon showed that the well's water is highly contaminated by pesticides that can affect the human system, especially the nervous system. The aim of this study is to assess the human exposure to pesticides, and to estimate the prevalence of two chronic neurodegenerative diseases including Alzheimer (AD) and Parkinson Disease (PD) in this region.

Methods: Cross-sectional study was performed from July 2015 to November 2017 in the region of Akkar-Lebanon to investigate the presence of AD and PD. A questionnaire was filled face to face with a random sample of 2833 inhabitants aged from 25 to 91 years obtained from 1264 surveys.

Results: In Akkar, the prevalence of AD and PD of people aged ≥65 years was respectively 10.30% and 10.91%, which exceed international percentages. The prevalence rate of both diseases increased as age group increases and their presence in females were higher than males. In addition, symptoms and signs to AD and PD were detected with high prevalence in inhabitants consuming well's water comparing to those that did not consume this water (p-values<0.0001), and a significant relationship has been associated between well's water consumption and PD appearance.

Conclusion: Future studies could be taken to identify the levels of pesticides in human blood, serum or urine.

Cite this article: Ouddane B, Chbib C, Ziade F, Baroudi M, Net S. Pesticides contamination and nervous disorders in an agricultural area in Akkar, Lebanon. A cross-sectional Study. A Epidemiol Public Health. 2020; 3(1): 1012.

Introduction

Pesticides regrouped a large number of organic compounds belonging to different chemical families that are used for removing weeds, fungi and insects and increasing agricultural productivity [1]. However, these products are environmental hazards due to their stability, persistence, and toxicity [2]. The severity of their effects is related to the individual chemical category of each pesticide, its toxicity, the way, the dose, the duration of exposure and the exposure route [3]. In order to reduce their risk, several directives regulated the levels of pesticides in the environment by setting maximum values. The most popular regulations are WHO, European directives, United States standards [4-6].

Humans became into contact with the residues of pesticides, through multiple pathways and routes either orally, inhalation, or skin absorption [3]. Living close to pesticides in agricultural areas like Akkar-north Lebanon is considered as sustainable long-term exposure to different toxic chemicals and increase the incidence of adverse human health effects including neurodegenerative diseases. Furthermore, many studies demonstrated that people exposed to pesticides had an elevated risk of Alzheimer's (AD) and Parkinson's Disease (PD) [7-9]. Approximately 90 % of the total contaminants are from oral exposure, including food and well's water [10]. Direct contamination of drinking well's water by pesticides has been documented in the literature [11,12].

In Akkar valley- northern Lebanon, many studies had shown an intensive use of pesticides and high contamination of analyzed groundwater samples by numerous herbicides and insecticides like Organochlorine (OCs), Organonitrogen (ONs) and Organophosphate pesticides (OPs). This area is vulnerable to long-term pesticides exposure with many publications reporting that the concentrations of OPs, OCs, and ONs exceeded the limits fixed by the European Union Drinking Water Directive [13,14]. Exposure to pesticides was associated with chronic respiratory symptoms and disease among Lebanese children [15]. However, little is known about the prevalence of nervous disorders and no modeling efforts exist in estimating the potential human health from exposure to pesticides posed by water or food consumption.

Based on this background, the present study has been aimed to assess the exposure to pesticides using the human health risk assessments approach, and to estimate the prevalence of two nervous disorders Alzheimer (AD) and Parkinson Disease (PD) in the north area of Lebanon namely Akkar valley.

Methods

Study area and population

Akkar is considered the most deprived rural regions in Lebanon (80,000 hectares of agricultural land), with a rural population of 80%. It is located in the North Governorate of Lebanon and limited by the Lebanese Syrian border from the north, and the Mediterranean seashore from the west (Figure 1). It covered 798 km^2 of territory with a high density of population. In 2015, the population of the governorate was estimated at 389,899 including 126,339 Syrian and Palestinian refugees [16]. Akkar is consists of 121 municipalities that present six main areas: Al-Sahel (Plain of Akkar), Middle and Higher Dreib, Joume, Shaffat and Qaita. Its capital "Halba", lies 30 km away from Tripoli [17].

The cultivated area represents one-third of the total area of Akkar. The governorate can be divided into two agricultural regions: (i) the mountainous region, where olive trees and all kinds of fruit trees are cultivated, and (ii) the plain of Akkar where is concentrated the main crop production regions such as Tobacco, citrus trees, cereals, potatoes, grapes and vegetables. The plain was considered as one of the poorest segment of the population in the country that has the lowest average individual income level and highest illiteracy rate in Lebanon. It suffers from a lack of services of all kinds, as well as the absence of governmental and non-governmental organizations in most villages. Furthermore, due to the absence of a public network for water distribution in this region, groundwater constitutes the principal source of drinking water for local inhabitants.

In addition, there is no control for the extensive use of pesticides, and a lack of awareness in farmers amongst the toxicity of these chemicals. Numerous pesticides such as OCs, OPs, and ONs has been detected at a high level in 15 groundwater samples collected from different villages on the Akkar plain [13]. Moreover, OCs were found in the agricultural soil of six villages at high levels ranged from 14.36 to 47.56 ng/g. The concentration level of heavy metals such as As, Zn, Cu, Pb, and Ni was not significant for this area except for cadmium, its concentration was detected at a moderate level [18].

Sampling technique and data collection

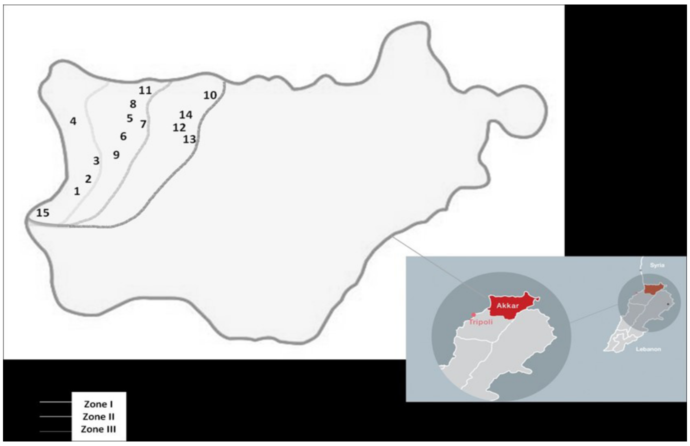

Figure 1: Location of survey area (Akkar and the 15 studied villages)

The present cross-sectional study was a part of a joint thesis project and was approved by Lille University – France and Lebanese University-Lebanon. It was carried out from July 2015 to November 2017 in a square of 100 Km^2. Fifteen most remote villages namely: *1-Kobbet Al Choumra; 2-Mqaitaa; 3-Qaabarine; 4-Qlaiaa; 5-Tall Mehyen; 6-Ballaneh Al Hissa; 7-Hissa; 8-Massoudieh, 9-Tal Andi; 10-Al Chaykh Ayach; 11-Tal Biri; 12-Tal Abbas El Gharbi; 13-Kouikhat; 14-Tal Abbas El Charqi; 15-Al Mhamra* were studied. These villages are located in the valley of Akkar and they represent around 50% of the plain area. The studied area was divided into three zones as shown in figure 1. The study population consisted of adult Lebanese population aged ≥ 25 years old and resident in the targeted area (15 villages) for at least 10 years before the study. Non-Lebanese inhabitants (Syrians and Palestinians) were excluded from this study. Subjects were also excluded if there was no consent for participation in the study, history of AD and PD around the family, and a history of other concomitant diseases potentially associated with these nervous disorders.

Face to face interviews was conducted by 35 students of the Faculty of Public Health III of Lebanese University. The students were familiar with the health issue problems related to the study and were trained in the house how to conduct the face to face interview, and all protocol procedures related to the study were discussed with them. An informed verbal consent form has been obtained from all participants. In total 2833 resident were included in the present study.

Questionnaire

Based on literature reviews, a detailed questionnaire including basic demographic and socioeconomic characteristics such as age, sex, and civil State, disease history and symptoms of AD and PD; exposure data via the type of water supply (public supply, private well, bottled water…). Furthermore, changes in behaviors and personality including anxiety, depression, and impairments in activities of daily living such as bathing, dressing, eating, loss of ability to communicate, neuropsychological problems and health-related quality of life and sleep disturbances were also included.

Based on previously published studies, participants were clinically diagnosed of probable AD if they met at least three of following criteria: 1) gradually worsening ability to remember new information, 2) disturbances in language and other cognitive functions, 3) confusion with time or place, 4) problems with words in speaking or writing [19].

While PD was diagnosed if subjects had cardinal signs like bradykinesia or slow movements, arthralgia, resting tremor, cogwheel rigidity, and posture instability associated with autonomic failure or reduction of daily living [20].

The questionnaire was approved by the Lebanese order of physicians in north Lebanon. A pilot study was performed and reflecting all the procedures, and the modifications needed in the design of the full-scale and validate the feasibility of the study.

Pesticides contamination and health Risk assessment

According to the US EPA Exposure Factors handbook, the average daily dose (ADD) of a pollutant via ingestion pathway is calculated according to the estimations of the magnitude, frequency and duration of human exposure to each pesticide using Equation below (Eq.1)

Equation 1. $ADD= (C* IR*EF*ED)/ (BW*AT)$,

Where ADD is the exposure duration (mg/kg-day), C is the concentration of contaminant in water (mg/l), IR is the intake rate (l/day), EF is the exposure frequency (day/year), ED is the exposure duration (year), BW is the body weight (kg), and AT is the average time (days).

In this study, C represents the concentration of pesticides content in the well's water of Akkar that has been determinate through water samples extraction using solid-phase extraction (SPE) followed by gas chromatography coupled with mass spectrometry (GC-MS). Detailed pesticides analysis method has been described in the previous work and summarized in table 1 (13). $I_{ng}R$ was estimated to 3 L/day (intake of drinking and cooking using well's water in liters per day). EF*ED/AT was defined as one representing a daily exposure to pesticides, and BW was 70 kg for adults.

Hence, the non-carcinogenic risk of pesticides was calculated as the hazard quotient (HQ) (Eq. 2) by dividing the average dose (ADD) to a specific reference dose (RfD) (mg/kg-day) (21- 23).

Table 1 shows the oral RfD and the calculated HQ.

Equation 2. $HQ= ADD/RfD$

If the value of HQ exceeds one, there is an unacceptable risk of adverse non-carcinogenic effects on human health, while if the HQ is less than one, it is at an acceptable level (24). For the risk assessment of mixture chemicals, the individual HQ are combined to form the hazard index (HI< 1: an acceptable level of risk; HI> 1 unacceptable level) [23].

Statistical analysis

Descriptive statistics were presented as number (percentage %) and means ± Standard Deviation (SD). Chi-square test was performed for nominal variables; T-test and ANOVA test were used for comparison for scale variables. One proportion Z-test was used to compare an observed proportion to a theoretical one. The significance level was established if p-value <0.05. Data analysis was performed using the "IBM SPSS statistics version 24" software package.

Results

European Union Drinking Water Directive specifies acceptable concentrations of 0.1 µg/L for individual pesticide and 0.5 µg/L for Σ pesticides, with the exception of aldrin, dieldrin, heptachlor, and heptachlor epoxide where the level was set at 0.03 µg/L (25-26). The concentrations of all OCs and OPs detected in well waters of Akkar plain were higher than the limits set by the DCE. Except for Endosulfan where its concentration in groundwater of Akkar was lower than 0.1 (0.05 µg/L) as shown in table 1 (13). Acceptable non-cancer health risks were observed for HCH, endosulfan, methoxychlor, dieldrin (HQ is very low: HQ< 0.1), DDT, heptachlor, dimethoate, parathion (HQ was between 0.2 and 1). Although human risk characterization of heptachlor epoxide, dieldrin, methylparathion, and disulfoton were higher than the acceptable level, their HQs were respectively 29.70, 2.33, 4.75 and 2.51. According to the HQ values, the HI of all the studied pesticides was at unacceptable levels (Σ_{HQ} of HCHs, DDT, heptachlor, heptachlor epoxide, endosulfan, methoxychlor, endrin, dieldrin, dimethoate, parathion, methylparathion, disulfoton =41.22).

A total of 2883 adults aged ≥ 25 years old were included in the final analysis of this study (65% of the total residents). In this population, 86.59% of the subjects, which constitute a population of 2453 of the local inhabitant, reported well water as their drinking and cooking water source without any treatment. The participants' demographic characteristics in the three zones were presented in Table 2. The male to female ratio was nearly equal (1:1) with no significant differences in sex ratios or mean age between the three zones (Table 2).

In this survey, two neurodegenerative disorders have been studied among the inhabitants of the plain of Akkar. Symptoms of AD and PD in the three zones were detailed in table 3. No significant difference has been shown between the three zones, where the prevalence of AD was varied from 4.74% (zone I) to 6.86% (Zone II) and for PD, prevalence was 4.19% at zone I, 3.73% at zone II and 5.90% at zone III. Furthermore, the prevalence of AD and PD symptoms varied widely between males and females, and with age groups. The prevalence of PD symptoms increased significantly (p-value < 0.0001) as age increases starting from 2.77% up to 10.91% for age groups [25-39] and

+65 years old respectively (Table 3). Similarly, the prevalence of AD symptoms increased significantly (p-value = 0.008) as age increases starting from 4.92% up to 10.30% for age groups [25-39] and +65 years old respectively (Table 3). Females were found significantly with a high prevalence of AD (9.44%) and PD symptoms (6.71%) compared to males (P<0.0001), where the prevalence of AD was 2.77% and the prevalence of PD was 1.80% (Table 3).

Most people with Alzheimer and Parkinson's diseases are diagnosed at age 65 or older, in the current study, 17 persons (10.30 %) aged +65 years had AD symptoms and 18 persons (10.91 %) had PD symptoms (Table 4). The presence of PD symptoms was significantly associated with well's water consumption (p-value = 0.0006). However, the results of this study did not reveal an association between the presence of AD symptoms and well's water consumption (Table 4).

Tables

Table 1: Concentrations, Oral RfD and calculated HQ of studied pesticides

Pesticides	Concentration (µg/L) *	Oral RfD (µg/kg/day)**	Calculated HQ
HCH (a)	1.30	0.3	0.22
DDT (b)	0.30	0.5	0.03
Heptachlor	4.22	0.5	0.36
Heptachlor Epoxide	9.01	0.013	29.70
Endosulfan	0.05	6.0	0.000
Metoxychlor	0.13	5.0	0.001
Endrin	0.28	0.2	0.06
Dieldrin	2.72	0.05	2.33
Dimethoate	3.78	0.2	0.81
Parathion	2.08	0.2	0.45
Methylparathion	27.72	0.25	4.75
Disulfoton	2.34	0.04	2.51

(a) HCHs: listed as y-HCH, (b) DDT: Listed as 4,4'-DDT.
* Average concentrations of OCs and OPs pesticides in wells water of studied villages (16)
** Oral RfD of pesticides (26)

Table 2: Characteristics of studied villages, total number of participants by sex and age, and pesticides concentration in wells water in the three zones, Akkar 2017.

	Zone I	Zone II	Zone III	Total
Altitude	[0-70] m	[55-150] m	[120-230] m	
Distance from sea shore	[0-6] Km	[6-12] Km	[12-18] Km	
Total population in the studied area	3247	4516	1991	9754
Number of Villages in the area	11	12	10	33
Sampled villages	5	6	4	15
Total population in sampled villages	1426	2215	717	4358
Total sampled individuals (age>=25)	908 (63.7%)	1501 (67.8%)	424 (59.1%)	2833
Sex				
Female	449(49.4%)	734(48.9%)	204(48.1%)	1387
Male	459(50.6%)	767(51.1%)	220(51.9%)	1446
Age				
[25-40]	480(52.9%)	759(50.6%)	204(48.1%)	1443
[40-65]	382(42.1%)	649(43.2%)	194(45.8%)	1225
>= 65	46(5.1%)	93(6.2%)	26(6.1%)	165

Table 3: Prevalence of AD and PD symptoms for participants aged ≥25 in the sampled villages, Akkar plain 2017

	Zone I	Zone II	Zone III	P-value
	n (%)	n (%)	n (%)	
Total participants age ≥ 25	**908**	**1501**	**424**	
Alzheimer Symptoms				
Confusion with time and place	26 (2.86%)	58 (3.86%)	18 (4.25%)	*0.328*
Difficulties in remembering	39 (4.3%)	97 (6.46%)	23 (5.42%)	*0.080*
Anxiety	33 (3.63%)	55 (3.66%)	18 (4.25%)	*0.838*
Depression	42 (4.63%)	84 (5.6%)	32 (7.55%)	*0.096*
Participants with AD	43 (4.74%)	103 (6.86%)	25 (5.90%)	*0.104*
Parkinson Symptoms				
Arthralgia	159 (17.51%	257 (17.13%)	89 (21.0%)	*0.177*
chronic resting tremor	47 (5.18%)	67 (4.46%)	28 (6.60%)	*0.222*
Tingling of articulations	69 (7.60%	57 (3.80%)	30 (7.08 %)	*0.201*
cogwheel rigidity	31(3.41%)	39 (2.60%)	20 (4.72%)	*0.507*
Slow motion	32 (3.52%	44 (2.93%)	17 (4.01%)	*0.483*
Difficulty with talking, walking	27 (2.97%	30 (1.20%)	12 (2.83%)	*0.274*
Participants with PD	38 (4.19%)	56 (3.73%)	25 (5.90%)	*0.479*

Table 4: Prevalence of PD and AD symptoms by age, sex, and wells water consumption - Akkar's plain 2017 (Data is presented as n (%).

		Parkinson			Alzheimer		
	n_{Total}	With	Without	P-value	With	without	P-value
Age							
[25-39]	**1443**	40 (2.77%)	1403 (97.23%)		71 (4.92%)	1372 (95.08%)	
[40-64]	**1225**	61 (4.98%)	1164 (95.02%)		83 (6.78%)	1142 (93.22%)	
≥65	**165**	18 (10.91%)	147 (89.09%)		17 (10.30%)	148 (89.70%)	
Total	**2833**	119 (4.20%)	2714 (95.80%)	*<0.0001*	171 (6.04%)	2662 (93.96%)	*<0.0001*
Sex							
Female	**1387**	93 (6.71%)	129 (93.29%)		131 (9.44%)	1256 (90.56%)	
Male	**1446**	26 (1.80%)	1420 (98.2%)	*<0.0001*	40 (2.77%)	1406 (97.23%)	
Total	**2833**	119 (4.20%)	2714 (95.8%)		171 (6.04%)	2662 (93.96%)	*<0.0001*
Wells water consumption							
Yes	**2453**	2340 (95.39%)	113 (4.61%)	*0.006*	2299 (93.72%)	154 (6.27%)	*0.1695*
No	**380**	374 (98.42%)	6 (1.58%)		363 (95.30%)	17(4.47%)	
Prevalence (age >65)							
Present study		10.91%			10.30%		
Reference 1		2% (37)		*<0.0001*	1.49% (35)		*<0.0001*
Reference 2		7% (38)		*0.049*	4.4% (35)		*0.0002*
Reference 3					8% (36)		*0.2762*

Discussion

This cross-sectional study was the first study to address the relation between HQ (Hazard Quotient) of pesticides exposure in well water and nervous disorders in Akkar plain- Lebanon. The study population resides in a largely agricultural region of Akkar-Lebanon with documented historical pesticides use. The wide-ranging use of pesticides had resulted in severe well's water pollution by OCs and OPs came from herbicides and insecticides application.

Based on the obtained results in previous publication, the well's water of Akkar cannot be considered as drinking water according to the OCs, OPs concentrations (µg/L) and the total pesticides concentration values that were above the recommended levels of DCE. It well noted that these concentrations approximately equal in Akkar villages. An interaction between different types of pesticides has been possible and contributes to multiple responses for the reason that exposure to these pesticides may induce birth defects, immune system dysfunction and increase the appearance of chronic disease including cancer, neurodegenerative diseases, reproductive problems (reduce male and female fertility), developmental toxicity, and respiratory effects (27-30).

Two important findings in this study. The first one is that the local people living in the study area generally were occupationally exposed during working on their private farms. Furthermore, they use well water at an average of 3.05 ± 0.24 L/day that is similar to the estimated average of 2 L/day for drinking and one more liter for cooking [21]. Moreover, the second was that the unacceptable human risk levels by heptachlor epoxide, and dieldrin, methylparathion and disulfoton. Furthermore, the primary mechanism of toxicity for the main groups of pesticides, particularly insecticides such as organochlorines, organophosphorus, and carbamates, is through targeting components of the nervous system [31].

World Health Organization currently estimates that a neurodegenerative disease [32] affects around a billion people worldwide. Many studies have been reviewed on the association between these diseases and pesticides [33,34]. Alzheimer's Disease (AD), the most frequent cause of dementia, is a progressive chronic neurodegenerative disease that progress through three stages preclinical Alzheimer's disease, Mild Cognitive Impairment (MCI), and dementia related to the criteria and guidelines classification**.** The greatest risk factor for Alzheimer's disease is advanced age. Most people with AD are diagnosed at age 65 or older around age 45-46. The present survey has shown that the prevalence of AD (10.30%) was higher than in other countries (1.94-8% in Europe and developed countries [35,36] and higher than the national prevalence (7.4%) (11% female and 2.7% for male). People younger than 65 had also developed the disease but with a low rate (Table 3). Furthermore, with the exception of the rare cases of Alzheimer's caused by known genetic mutations, the strong association of AD with increasing age for both female and male (Table 3) may reflect that advanced age alone is not sufficient to cause the disease. Other cumulative effects of multiple risks, including biological and psychosocial factors such as diabetes and cardiovascular diseases, and exposure to environmental pollutants. Parkinson's Disease (PD) - the most common movement disorder besides essential tremor and the second most common neurodegenerative disease progress slowly with age into 6 stages, which means that development, may last for 20 years. PD is a disease of aging, with a peak age between 60 and 65 years, approximately 1–2% (37).

In Akkar, the prevalence for the population over 65 years who suffered from PD was found in this study (10.91%) higher than the prevalence reported in the world (1-7%) [38]. Furthermore, PD has been recorded in young adults (prevalence was 4.98% and 2.77% for people aging [40-65] and [25-40] years old respectively. Since the prevalence was very high, with the absence of genetic risk factors, this may be related to the exposure to toxic environmental factors including neurotoxic pesticide that interfere with neurotransmission, and function of ion channels in the nervous system and contribute to increasing the risk of PD [39].

In this study, sex differences in the risk of developing nervous disorders have been shown with an overall ratio (F: M) female / male ratio of four and three for PD and AD respectively. For AD, this case was similar to the results shown in studies of Fratiglioni et al. (2000) and Ferretti et al. (2018) [35,40] where women showed faster cognitive decline after diagnosis of mild cognitive impairment (MCI) or AD dementia than men [40]. While, for PD, in almost of studied cases all over the world. This ratio has been reversed; where men were 1.5 times more likely to have Parkinson's than women [20].

Exposure to numerous classes of pesticides during consumption of well's water was also evaluated. High significant association has been reported between water consumption and the prevalence of PD (p-value<0.05) (Table 4). Although, the presence of AD has been dependent neither by quantity nor by duration, the p-value were >0.05 (Table 4). This can be indicative of high susceptibility to the neurotoxicity of pesticides, though, consumption of well's water presumably contaminated by a greater number of OCs and OPs pesticides, specifically Heptachlor Epoxide, Dieldrin, Methylparathion and Disulfoton. Further, increased the risk of PD and AD compared with residents without such exposures from well water.

The study has a few limitations. The hazard risk resulted from the cumulative high doses of pesticides molecules was not estimated in this study, this was difficult due to the fact that the interaction effects of identified OCs and OPs are very complicated. The limited knowledge about the amount and the temporal change of crops patterns near homes, the average quantity of pesticides in food intake may also influence the survey results.

Conclusion

In the region of Akkar, the residents were still exposed to hazardous levels of few molecules of OCs and OPs pesticides founded in well's water demonstrated by the permanent use of this water for drinking and cooking.

This screening survey proved a higher prevalence of AD and PD in the people more exposed to pesticide than others less exposed did. It supports epidemiological studies that associate exposure to pesticides with increased risk of AD and PD, and it identified the specific molecules heptachlor epoxide, dieldrin, methylparathion and disulfoton that are associated with the risk of PD in the Akkar plain population.

It is recommended that more research on the prevalence and impact of water consumption on human health is needed which require national intervention. More studies could be established in order to identify the levels of pesticides on serum, blood, urine in the inhabitants of this region or the breast milk for confirming the present supposition. Thus, the human health risk assessment depends not only on the ingestion of contaminated water but also by inhalation of polluted air and on ingestion of food. Consequently, evaluation of air, soil and vegetable pesticides contamination in the plain of Akkar could be realized.

Acknowledgements

We gratefully acknowledge the financial support of the association AZM & SAADE in Lebanon and the PHC CEDRE project.

We thank the volunteers (Students of the Lebanese university -Faculty of public Health- in Tripoli) for their participation; without them the present study could not have been completed

References

1. Blasco C, Font G, Picó Y. Comparison of microextraction procedures to determine pesticides in oranges by liquid chromatography–mass spectrometry. Journal of Chromatography A. 2002; 970: 201-212.
2. Jiménez Ó P, Pastor R M P. Estimation of measurement uncertainty of pesticides, polychlorinated biphenyls and polyaromatic hydrocarbons in sediments by using gas chromatography–mass spectrometry. Analytica chimica acta. 2012; 724: 20-29.
3. European Food Safety Authority (EFSA). Opinion of the Scientific Panel on Plant Protection products and their Residues to evaluate the suitability of existing methodologies and, if appropriate, the identification of new approaches to assess cumulative and synergistic risks from pesticides to human health with a view to set MRLs for those pesticides in the frame of Regulation (EC) 396/2005. EFSA Journal. 2008; 6: 705.
4. World Health Organization. International code of conduct on the distribution and use of pesticides: guidelines on pesticide advertising. Geneva: World Health Organization. 2008.
5. DCE. Drinking water -Essential quality standards.
6. EPA. [http://water.epa.gov/drink/contaminants/index.cfm#List]
7. Nandipati S, Litvan I. Environmental exposures and Parkinson's disease. International journal of environmental research and public health.2016; 13: 881.
8. Sanchez-Santed F, Colomina M T, Hernandez E H. Organophosphate pesticide exposure and neurodegeneration. Cortex. 2016; 74: 417-426.
9. Van Maele-Fabry G, Hoet, P, Vilain F, & Lison D. Occupational exposure to pesticides and Parkinson's disease: a systematic review and meta-analysis of cohort studies. Environment International.2012; 46: 30-43.
10. Fu L, Lu X, Tan J, Zhang H, Zhang, Y et al. Bioaccumulation and human health risks of OCPs and PCBs in freshwater products of Northeast China. Environmental pollution. 2018; 242: 1527-1534.
11. Gupta S D, Mukherjee A, Bhattacharya J, Bhattacharya A. An Overview of Agricultural Pollutants and Organic Contaminants in Groundwater of India. In Groundwater of South Asia, Springer, Singapore. 2018; 247-255.
12. Song D, Park S, Jeon S H, Kim KI, Hwang, JY et al. Simultaneous Analysis of 13 Pesticides in Groundwater and Evaluation of its Persistent Characteristics. Korean Journal of Soil Science and Fertilizer. 2017; 50: 434-451.
13. Chbib C, Net S, Hamzeh M, Dumoulin D, Ouddane B et al. Assessment of pesticide contamination in Akkar groundwater, northern Lebanon. Environmental Science and Pollution Research. 2017; 25: 14302-14312.
14. El-Osmani R, Net S, Dumoulin D, Baroudi M, Bakkour H et al. Solid phase extraction of organochlorine pesticides residues in groundwater (akkar plain, north Lebanon). International Journal of Environmental Research.2014; 8: 903-912.
15. Salameh PR, Baldi I, Brochard P, Raherison C, Saleh B. A et al. Respiratory symptoms in children and exposure to pesticides. European Respiratory Journal. 2003; 22: 507-512.
16. UNHCR. "Akkar Governorate Profile". 2015.
17. Localiban. Mohafazah de Akkar. 2017.
18. Chbib C, Sahmarani R, Net S, Baroudi M, Ouddane B. Distribution of Organochlorine Pesticides and Heavy Metals in Lebanese Agricultural Soil: Case Study—Plain of Akkar. International Journal of Environmental Research. 2018; 12: 631-649.
19. Qiu C, Kivipelto M, von Strauss E. Epidemiology of Alzheimer's disease: occurrence, determinants, and strategies toward intervention. Dialogues in clinical neuroscience.2009; 11: 111.
20. Chen SY, & Tsai ST. The Epidemiology of Parkinson's disease. Tzu Chi Medical Journal.2010: 22: 73-81.
21. US EPA. Definitions and general principles for exposure assessment. Guidelines for exposure assessment. 1992.
22. US EPA I. US Environmental Protection Agency's integrated risk information system.
23. Wongsasuluk P, Chotpantarat S, Siriwong W, Robson M. Heavy metal contamination and human health risk assessment in drinking water from shallow groundwater wells in an agricultural area in Ubon Ratchathani province, Thailand. Environmental geochemistry and health. 2014. 36: 169-182.
24. US EPA (US Environmental Protection Agency) Baseline human health risk assessment Vasquez Boulevard and I-70 superfund site, Denver CO. 2001.
25. European Union, Common position (EC) 12767/97 Adopted by the council on 16 December 1997 with a view to the adoption of council directive on the quality of water intended for human consumption. Inter-institutional file 95/0010 (SYN). 1997.
26. Hu Y, Qi S, Zhang J, Tan L, Zhang J et al. Assessment of organochlorine pesticides contamination in underground rivers in Chongqing, Southwest China. Journal of Geochemical Exploration.2011; 111: 47-55.
27. Sabarwal A, Kumar K, Singh R. P. Hazardous effects of chemical pesticides on human health-cancer and other associated disorders. Environmental toxicology and pharmacology. 2018; 63: 103-114.
28. Ma Y, He X, Qi K, Wang T, Qi Y et al. Effects of environmental contaminants on fertility and reproductive health. Journal of Environmental Sciences. 2018; 77: 210-217.
29. Shaffo F. C, Grodzki A. C, Fryer A. D, Lein P. J. Mechanisms of organophosphorus pesticide toxicity in the context of airway hyperreactivity and asthma. American Journal of Physiology-Lung Cellular and Molecular Physiology. 2018; 315: L485-L501.
30. Mostafalou S, Abdollahi M. Pesticides and human chronic diseases: evidences, mechanisms, and perspectives. Toxicology and applied pharmacology. 2013; 268: 157-177.
31. Karami-Mohajeri S, Nikfar S, Abdollahi M. A systematic review on the nerve–muscle electrophysiology in human organophosphorus pesticide exposure. Human & experimental toxicology.

2014; 33: 92-102.

32. Bongaarts J. World Health Organization: Working Together for Health: The World Health Report 2006. Population and Development Review. 2006; 32:790-792.

33. Gretebeck R J, Ferraro K F, Black DR, Holland K, Gretebeck K A. Longitudinal change in physical activity and disability in adults. American journal of health behavior. 2012; 36: 385-394.

34. Wolinsky FD, Bentler SE, Hockenberry J, Jones MP, Obrizan M et al. Long-term declines in ADLs, IADLs, and mobility among older Medicare beneficiaries. BMC geriatrics. 2011; 11 : 43.

35. Fratiglioni L, Launer LJ, Andersen K, Breteler MM, Copeland, JR et al. Incidence of dementia and major subtypes in Europe: A collaborative study of population-based cohorts. Neurologic Diseases in the Elderly Research Group. Neurology. 2000; 54: S10-5.

36. Kalaria RN, Maestre GE, Arizaga R, Friedland RP, Galasko, D et al. Alzheimer's disease and vascular dementia in developing countries: prevalence, management, and risk factors. The Lancet Neurology. 2008; 7: 812-826.

37. Lotankar S, Prabhavalkar KS. Potential therapeutic targets for the treatment of parkinson's disease. 2018.

38. Poewe W, Seppi K, Tanner CM, Halliday GM, Brundin P et al. Parkinson disease. Nature reviews Disease primers. 2017; 3: 17013.

39. Costa LG, Giordano G, Guizzetti M, Vitalone, A. Neurotoxicity of pesticides: A brief review. Front Biosci. 2008; 13: 1240-1249.

40. Ferretti MT, Iulita MF, Cavedo E, Chiesa PA, Dimech AS et al. Sex differences in Alzheimer disease-the gateway to precision medicine. Nature Reviews Neurology. 2018; 457-459.