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Association of Environmental Exposure to Heavy Metals with Chronic Kidney Disease (CKD) In Patients from White Nile Province, Sudan.

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Abstract

This research was focused on assessment of Chronic Kidney Disease (CKD), due to the contamination of water, in White Nile Province, Sudan with heavy metals, agrochemicals, hard water, ionicity, and climate changes. Nevertheless, the levels of any of the pollutants or conditions reported in this water are inconsistent not correlated with the prevalence of the disease, and are too low to cause (CKD). The most common cause of chronic kidney disease (CKD) among all groups was diabetes mellitus (46.50%); followed by hypertension (46.50%); chronic glomerulonephritis (7.64), while other causes account for only (9.55%). The highest prevalence of CKD was recorded in Al-Dwueim, followed by Allahamed localities, with a percentage of (22.9% and 17.8%), respectively. The highest prevalence of the cases was recorded in patients of the range age of 31-50 years , followed by patients from the group 51-70 years old, and least in the group of 71-90 years old. Famers recorded a frequency of (20.38%) and sponsors recorded a frequency of (17.20%), while, among groups of other occupation a high frequency of (42%) was recorded. The level of education reflected a high frequency of CKD among the individuals of primary education, followed by individuals of secondary education, while the lowest frequency was recorded among illiterates. People living in red brick building, recorded the highest number of CKD patients (142 patients) while only (5 patients) who live in wool building were recorded (Figure 6). On the other hand, high prevalence of CKD (113 patients) was recorded in groups who do not take herbs, while the more patients (44) were recorded among individuals who take herbs. All results showed significance of ($P \leq 0.05$).

Keywords: functional glomerular tissue, anthropogenic activities, algae toxins, homocysteine, geographical distribution, Drinking-water supplies, CKD of multifactorial origin (CKDmfo), heavy metals.

Introduction

Chronic kidney disease is typically defined by a progressive loss of functional glomerular tissue followed by proteinuria and loss of glomerular filter function, but, in contrast, there is no signature feature that characterizes CKDu. The pollution of water and food through human waste and anthropogenic activities, including industrial waste and agricultural runoff, is a mounting problem worldwide. Water pollution from microbes causes identifiable diarrheal illnesses. The consumption of water contaminated with heavy metals, fluoride, and other toxins causes insidious illnesses that lead to protracted, non-communicable diseases and death. Chronic kidney disease of unusual/uncertain/unknown aetiology is one such example, began to manifest in the mid-1960s in several dry-zonal agricultural societies in developing economies that are located around the equator. In Sri Lanka, such a disease is affecting the North Central Province, the rice bowl of the country that first appeared in the mid-1990s. Several potential causes have been postulated, including heavy metals, fluoride, cyanobacterial and algae toxins, agrochemicals, and high salinity and ionicity in water, but no specific source or causative factor has been identified for CKD of multifactorial origin (CKDmfo). Three large studies conducted in the recent past failed to find any of the postulated components (heavy metals, cyanobacterial toxins, fluoride, salinity, or agrochemicals) at levels higher than those deemed safe by the World Health Organization and the US Environmental Protection Agency. At the reported low levels in water and with the heterogeneous geographical distribution, it is unrealistic to expect any of these components individually could cause this disease. However, the additive or synergistic effects of a combination of factors and components, even at lower exposure levels, together with malnutrition and harmful behaviours, and/or a yet-unidentified (or not investigated) toxin, can cause this epidemic. Because the cause is unknown, scientists need to work on broader hypotheses, so that key causative elements are not missed. Agriculture is important in rural livelihood in the State, yet people engage themselves in other livelihood alternatives, particularly wage and skilled labor along with high unemployment and high dependency rates. Agriculture and wage-earning jobs have different weights in different localities with different impacts on per capita incomes, calling for geographical targeting. Priorities for interventions in agriculture should be directed to Tandalti, Kosti, Alsalam and Algabalain, off farm job opportunities become of pressing need in Rabak, Umrimta and Alquiteina, further in Alsalam and Algabalain due to high unemployment and particularly ear-marked to the high portion of housewives in all localities. The types of interventions would include provision of agricultural inputs, extension services and credit to promote improved technology use, widening of irrigation options and promotion of small-scale opportunities in and outside agriculture. The incidence of food deprivation is generally considerable and varies among localities. The aforementioned interventions for improving agricultural and non-agricultural livelihood activities are of relevance in the medium and long term, yet direct targeting through food aid and Zakat is needed in the short run. Priority targets should be directed. (Walekhwa at al.,2009).

Materials and Methods

Study area

This study was carried out during the period (April 2016 - October 2020) within AlDawim locality in the White Nile State, Sudan. The State is home to significant numbers of refugees of about (153,000 in 2006) forming nearly 10% of the population; and also a transit point for Internally displaced people s(IDPs) returning to the south and south of Kordofan. Most of these Internally displaced peoples (IDPs) have been settled in many camps.

Study population

The population of this study area was of different multi - ethical groups. A total of 157 patients (77 males and 80 females aged, 10 year to 80 years), with early stage (preserved renal function), were randomly selected from the outpatient clinic in the hospital. Another 157 healthy persons (77 males and 80 females, ages 19 to 80 years) were selected as control. Weight and height were recorded for each individual and body mass index (BMI) was calculated (kg/m^2). Inclusion criteria for case selection included confirmed renal failure and signing the inform consent. Exclusion criteria for case selection included patients with: Macro-albuminuria, congestive cardiac failure, diabetic nephropathy ketonuria, urinary tract infection and pregnant women.

Demography data

Data on demographic information, lifestyle risk factors, and personal medical history of patients were gathered by designed standard questionnaires and recorded by trained staff. Information included the following:

1. Patient's age, sex and time of onset and duration of renal failure.
2. Total duration of renal failure, the drugs the patient was taking, the dosages and the regularity of the treatment.
3. All details regarding the presenting complaints.

Research Ethics

The proposal of this study was approved by the Research Committee in the Faculty of Medicine and Health Science, University of Al-butana. Verbal informed consent was obtained from all study subjects (3.7.20016).

Collection and analysis of water samples

Water digestion and analysis

A volume of 100 ml of the sample was measured using a 100 ml volumetric flask and put in a conical flask with 5 ml of concentrated nitric acid. The mixture was heated slowly on a hot plate and

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evaporated to about 20 ml ensuring that the water did not boil. A further 5 ml of concentrated nitric acid was added and the beaker was covered with a watch glass while heating continued. Nitric acid continued to be added until the solution appeared light colored and clear. Another 2 ml of concentrated hydrochloric acid was added and heated slightly to dissolve any remaining residue. Few drops of hydrogen peroxide were also added to ensure complete digestion. The solution was filtered and the filtrate was transferred to a 100 ml volumetric flask and made up to the mark with distilled water (Radojovenic and Bashkin, 2006).

Methods

Water regimented or treated to make it potable the house and main source of cooking fuel and different cooking techniques: (1) soaking, (2) pressure cooking, and (3) normal cooking. Mineral content was analyzed using flame photometry and nitro-vanado-molybdate colorimetry.

Collection of soil samples

Sampling sites were chosen in line with anthropogenic sources of heavy metals. Samples were taken from Abo Qroon, Alhduab, Al-Dawim, Al-Quitam, Al-Quitaina, allahamd, Kosti, Rabak, shabasha, the mandarib, and Arshul Mountain. Twenty four soil samples (three replicates) were collected from the surface from various locations to cover the industrial area in the White Nile state, and 10 meters to1km far from the bank the White Nile for areas that are covered by the flood. The soil samples were labeled according to the regions from which they were obtained. One gram of each well mixed sample was put into 250 ml glass beaker and digested with 24 ml of nitric and hydrochloric acids and then evaporated to near dryness. The soil samples were then dissolved in 10 ml of 2% nitric acid, filtered and then diluted to 100 ml with distilled water according to (Begum et al., 2009). One gram of randomly selected soil powder was spiked with three different concentrations of heavy metals one at a time (1.0, 1.5, 2.0 ppm) each run in with the ICP9000 machine. Stock solution for each of the heavy metals Lead Zinc Manganese Cadmium and Chromium was prepared and used to generate a calibration curve for each metal, before the measurement of the concentration in the soil and water samples. The digestion method and atomic absorption spectroscopy analysis were validated by recovery method. One gram of randomly selected soil powder was spiked with three different concentrations of heavy metals one at a time (1.0, 1.5, 2.0 p.p.m.) each run in with the ICP9000 machine. This was followed by the digestion of the spiked samples and determination of metal concentration using ICP9000 . Blank or unspiked samples were digested through the same process and analyzed by same AAS. The amount that was recovered after digestion of the spiked samples was used to calculate % recovery (Al-weher, 2008). A mean recovery of the matrix was evaluated at 95% confidence level (Borosova et al., 2002). Buck scientific (210 VGF) ICP-MS machine was used for analysis. Its parameters were set according to the specifications given in the manufactures manual including lamp current and fuel system of air/acetylene flame. The AAS machine had a picking meter that indicated when the optimum conditions had been realized. Its optimization was automatic.

Statistical analysis:

Values were presented at mean ± Standard deviation (SD) in mg of all measure variables. Students t-test and one-way ANOVA with Dunnett' spots test were performed using Graph Pad Prism version 6 for windows, Graph pad software, San Diego California USA, www. Graphpad.com. p values ≤ 0.05 were considered significant.

Results

Demographic Data

The most common cause of chronic kidney disease (CKD) among all groups was diabetes mellitus (46.50%); followed by hypertension (46.50%); chronic glomerulonephritis (7.64), while other causes account for only (9.55%), (Figure 1). The highest prevalence of CKD was recorded in Al-Dawim (Table 3.2), followed by Allahamed, with a percentage of (22.9% and 17.8%), respectively (Figure 2).

Table (3.1). The frequency of renal failure (CKD) recorded among patients from different of localities.

Locality	Frequency	Percent (%)	alid Percent	Cumulative Percent
Abo Qroon	12	7.6	7.6	7.6
amonta	11	7.0	7.0	14.6
Al Dawim	36	22.9	22.9	37.6
Al-Quitana	16	10.2	10.2	47.8
Allahamd	28	17.8	17.8	65.6
Arshul Mountain	10	6.4	6.4	72.0
Kosti	11	7.0	7.0	79.0
Rabak	11	7.0	7.0	86.0
Shabasha	10	6.4	6.4	92.4
The mandarib	12	7.6	7.6	100.0
Total	157	100.0	100.0	

The frequency of renal failure among the different age groups is shown in (Table 3.3).The highest prevalence of the cases was recorded in patients of the range age of 31-50 years , followed by patients from the group 51-70 years old, and least in the group of 71-90 years old

Table (3.2). The prevalence and frequency of renal failure (CKD) recorded among patients from the different age groups.

Age (Years)	Frequency	Percent (%)	Valid percent (%)	Cumulative percent (%)
10-30	34	21.7	21.7	21.7
31-50	71	45.2	45.2	66.9
51-70	50	31.8	31.8	98.7
71-90	2	1.3	1.3	100.0
Total	157	100.0	100.0	

Famers recorded a frequency of (20.38%) and sponsors recorded a frequency of (17.20%), while, among groups of other occupation a high frequency of (42%) was recorded (Table 3.4 and Figure 4).

Table (3.3). The frequency of renal failure (CKD) recorded among patients of different of occupations.

Types of occupation	Frequency	ercent (%)	Valid Percent (%)	Cumulative Percent (%)
Farmers	32	20.4	20.4	58.0
Sponsors	27	17.2	17.2	31.8
Merchants	14	8.9	8.9	8.9
Teachers	9	5.7	5.7	37.6
Engineers	5	3.2	3.2	12.1
Doctors	4	2.5	2.5	14.6
Others	66	42.0	42.0	100.0

The level of education reflected a high frequency of CKD among the individuals of primary education (Table 3.5), followed by individuals of secondary education, while the lowest frequency was recorded among illiterates.

Table (3.4). The frequency of renal failure (CKD) recorded among patients of different of education levels.

Types of Education	Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Primary	86	54.8	54.8	54.8
Secondary	55	35.0	35.0	89.8
University	10	6.4	6.4	96.2
Illiterate	6	3.8	3.8	100.0
Total	157	100.0	100.0	

People living in red brick building (Table 3.4) recorded the highest number of CKD patients (142 patients) while only (5 patients) who live in wool building were recorded (Figure 6). On the other hand, high prevalence of CKD (113 patients) was recorded in groups who do not take herbs (Table 3.7) while, the more patients (44) were recorded among individuals who take herbs (Figure 7).

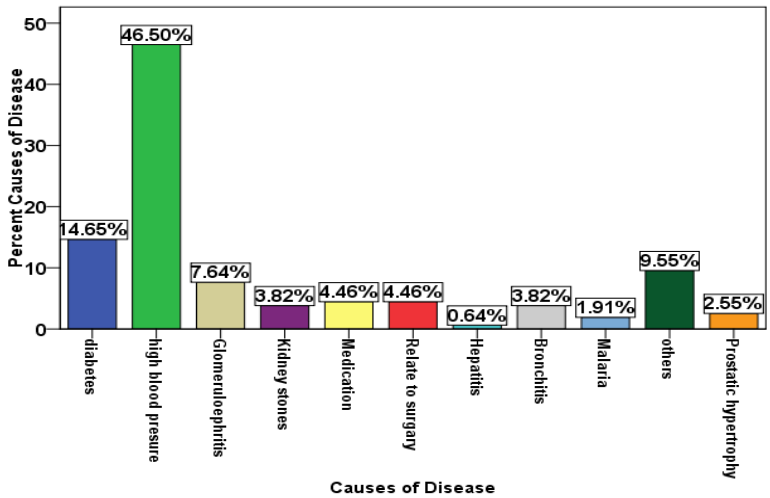

Figure (1).Diagrammatic representation showing the percentage of the most common causes of renal failure (CKD) among the examined patients.

Table (3.5). The frequency of renal failure (CKD) recorded among patients living in different types of housing.

Types of housing	Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Straw building	9	5.7	5.7	5.7
Red brick building	142	90.4	90.4	96.2
Wool building	5	3.2	3.2	99.4
Zinc building	1	0.6	0.6	100.0
Total	157	100.0	100.0	

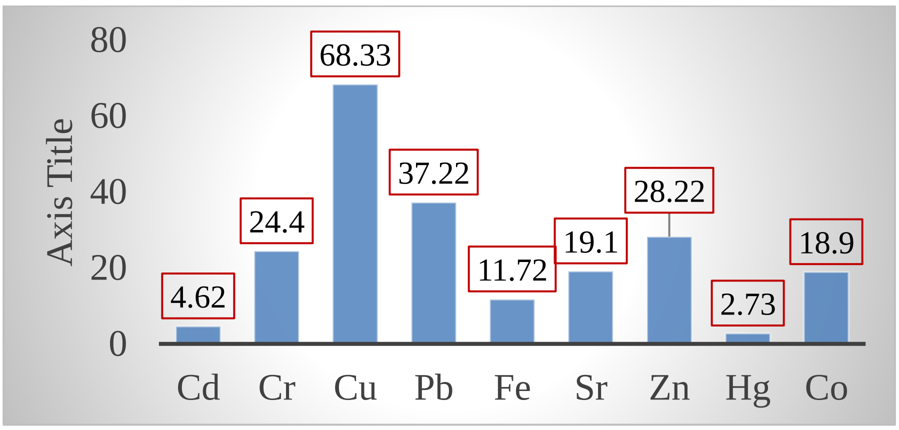

Figure (2). Average concentration of heavy metals in soil samples from nine cities

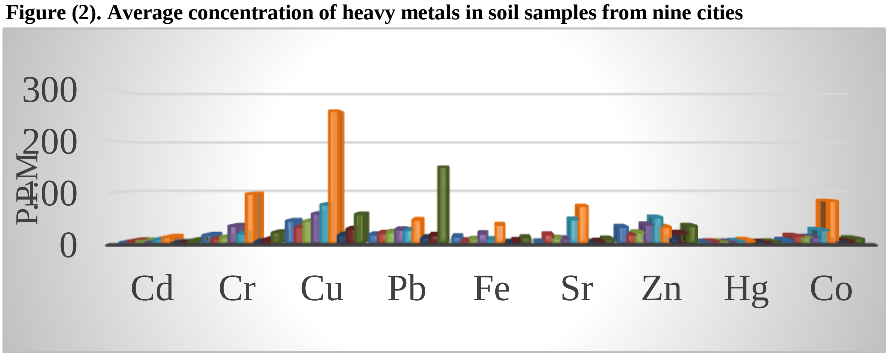

Figure 3). Mean concentration of heavy metals in soil samples from nine cities of the White Nile State.

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Although, fertilizers, pesticides and mulch are important agricultural inputs for production (Zhang and Zhang, 2007

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