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Impact of Water Pollution on Human Health in the Central African Republic

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Abstract

Bacterial contamination of waters and their impacts on human health in the Central African Republic is a pollution problem that goes far back in time. Today, water quality is impaired, including the contamination of fecal microorganisms, excessive use of agrochemicals, uncontrolled discharges from industries and solid and liquid waste from households and municipal. Most of people in Central Africa use water directly from the wells and rivers water for their domestic activities include drinking. These works highlight the bacteriological and nitrate pollution of surface and groundwater streams and how can impair public health. Many reports concluded that this pollution came from poor sanitation wastes/extracts. Other studies have revealed the presence of nitrates and coliform bacteria in groundwater in agricultural areas it concludes that, this pollution comes from the reuse of untreated wastewater in agriculture. Rivers and lakes seem to be most contaminated sources because are most exposed to waste. Human activities and poor municipal waste control contribute to water pollution and results to serious health problems. Main data in this review study are collected in various existing studies by many researchers and published in international and national journals, but also by non-governmental organizations and the Central African Government reports.

Key words: clean water, water pollution, contamination, pathogenic microorganisms.

INTRODUCTION

The freshwater resources of the planet are facing increasing threats (GWP, 2009). Access to clean water is at the heart of most public health problems facing developing countries including the Central African Republic. However, significant pressures on water supplies in various parts of the world are contributing to a worrying deterioration in their quality (Wikipédia/Geopolitics of Water, 2009). The World Health Organization estimates that nearly 500 million people each year are affected by waterborne diseases, and 20 million of these people die although microbiological quality of water remains the primary public health concern worldwide (Gantzer et al., 1998; UN, 2007; Constantine et al., 2007). Among the factors responsible for these infections bacteria take a great concern for polluted water. Louis Pasteur portrayed that "we drink 90% of our diseases." Additionally, bacterial contamination in water environment is a natural phenomenon in which man plays the role of primary

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contaminant, but also secondary receiver of bacteria present in the medium (Gantzer et al., 1998). Currently, water quality is impaired, including the excessive use of agrochemicals, uncontrolled discharges from industries, solid and liquid waste from households (Saab et al., 2007; Abu Jawdeh et al., 2000). Preservation of water quality and its equitable use are necessary for sustainable development and its contribution to maintaining health (Makoutodé et al., 1999).

Unfortunately, in Central Africa, more than three quarter of the population suffers from diseases of or poor quality of the raw material essential for human life. This kind of terrible living conditions favor the deaths of nearly 10,000 people a day, 20 times the number killed in wars in which a large majority of child (Tomkins et al., 2004). Despite the measures taken and efforts on the international level, water is still and remains at the center of much debate (Dinar, 2000; Marino and Boland 1999). Water is treated as an infinite free good and the issues that are related are many. Water rate the social life of the family or village (Alley et al., 2002).

Water is part of our natural environment like the air we breathe and the land that supports us and feeds us; it is a familiar part of our everyday life (Nguimalet et al., 1999). In 1980, in developing countries excluding China, 3 out of 5 people had no water (Alley 2002 & SEM 2002). However, water supplies are adequate they are daily threats by pollution while demand increases. According to a UN report, the Central African population is increasing exponentially while water availability is declining. Microbiological infections are the most common water related diseases mainly caused by three types of organisms which are bacteria, viruses and protozoa (Zogo, 1980; Health Canada, 2003).

In developing countries water problem is more serious because of the lack of good governance, lack of professional and even financial hardship (PCRWR, 2000). The Central African Republic as well as other developing countries always have water shortage and rampant pollution. To regress these infectious and parasitic diseases transmitted by water, International Decade of Drinking Water and Sanitation (IDWSSD, 1981-1990) promoted a policy to raise the level of health and population production of drinking water available (Director Inter institutional Cooperation Committee for the Decade, 1990; WHO, 1994; Comlanvi, 1994). Despite the immense of freshwater resources of Central Africa, the country continued to suffer from polluted water and faces a major challenge in the water sector: which is increasing in low rate of access to quality drinking water with total absence of bacteria fecal contamination from its rapidly growing population. (WHO, 1993, MSP 2001; Miquel, 2003). CAR suffered decades (2003-2013) of underinvestment, exacerbated by the destruction of facilities during the conflict that greatly deteriorating infrastructure and water services in the country. The access to safe drinking water rate is 25% which is one of the lowest amount in Central Africa (Mokofio et al., 1991).

CAR is sufficiently endowed with water resources enabling it to meet the needs of the population (MMEH, 1999). Unfortunately, these resources are also at risk of bacteriological, chemical and biological pollution, especially in areas of very high concentrations of people (ASNA, 2010). In the current difficult situation the country unfortunately not reach the seventh goal of the Millennium Development Goals (MDGs) of drinking water.

This review, quoted example of excellent detailed study by (Mokofio et al., 1991) on the bacteriological quality of water from wells, boreholes sources in some districts of the city in Bangui. Results of study conducted by (Mokofio et al., 1991) show that almost all wells and

surface water is contaminated by fecal germs and pollution is the most important that the district is low altitude (see results in table 1 below). Private Wells and well maintained drilling generally have a low level of pollution. The poor quality of drinking water available in the country forces the population to obtain a costly alternative in the form of mineral water available commercially packaged in plastic bottles. However, this water commercially available is also not completely suitable due to lack of proper monitoring in of processing plants (Roseman, 2005). The low purchasing power of the population is an obstacle. Given this situation, the majority of the Central African population is exposed to contaminated water that can cause health problems. According Capo-Chichi (2009), many population are still using untreated water from well or the waterways, for drinking, even in cities where treated water is supplied. However, they usually contain potential contaminants including pathogenic microorganisms such as bacteria (Goss, 1998).

Indeed, some bacteria, such as fecal coliforms represented by Escherichia coli (E. coli), can be harmful to humans and some other animals .Thus the pollution of these water sources does not spare withholding water installed in the Ubangi River, which feeds the unique water Distribution Company of Central Africa (SODECA. People who handle these waters without treatment for various needs are exposed to all kinds of waterborne diseases. The exponential pollution of these water sources in Central Africa and its impact on human and environmental health is a subject of great concern. Central African government and development partners or investors should put particular emphasis on this problem of water pollution and their effects on human health, because 75% of water in Central African population are supplied from wells, boreholes and surface water (Aziz et al., 2005), surface water is another main source of drinking water and other domestic uses.

The present review aims to determine the bacteriological pollution of raw water from drilling water, wells and surface water in different parts of the Central African capital.

CHEMICAL CONTAMINANTS IN WATER (DIFFERENT POLLUTANTS)

A pollutant is a natural substance and outcome of human activities that, when present in excessive amounts in the environment can have harmful effects on living things. According to the famous Swiss alchemist Paracelsus physician (1493-1541) "Nothing is poison, everything is poison, only the dose makes the poison. “This Observation applies to pollutants, some of which are active at extremely low doses (of the order of gram per liter of water billionth) .However some substances are more toxic than others and are more harmful to human health and the environment. According to Tchobanoglous and Schroeder (1985) these substances are considered to be biological and chemical impurities from the water (see table below) which are pathogens (viruses, bacteria and protozoa), inorganic pollutants (salts and acids), and ions (nitrates, phosphates, sulfates Ca+2, Mg+2 and F-). In Central Africa, the most commonly encountered substances in groundwater and surface water are: calcium, chloride, magnesium, sodium, potassium, bicarbonates, sulfates, phosphates, and nitrates. Traces of other ions such as lead, copper, iron, manganese, and arsenic can also occur, these chemical elements found in the state of traces in water and when they exceed a limit, they are harmful and cause serious health problems in humans and other organisms in the biotope.

In the Central African industrial urban effluent discharges, pesticides and fertilizers in agriculture as well as livestock wastes are the main sources of pollution.

Table 1. Chemical and biological impurities in water according to (Tchobanoglous and Schroeder, 1985).

The impurities existing in the water		
ORIGIN	Positive ions	Negative ions
Contact of water with minerals, soil and rock	Calcium (Ca^{+2}) Ferrous ion (Fe^{+2}) Magnesium(Mg^{+2}) Manganese(Mn^{+2}) Potassium((K^{+}) Sodium(Na^{+}) Zinc(Zn^{+2})	Bicarbonate(HCO_3^{-}) Carbonate(CO_3^{-2}) chloride (Cl^{-}) fluoride (F^{-}) Nitrate (NO_3^{-}) Phosphate(PO_4^{-3}) Hydroxide(OH^{-}) Borates($H_2BO_3^{-}$) Silicates(H_3SiO_4) Sulfate(SO_4^{-2})
atmosphere, in rain	Hydrogen ion (H^{+})	Bicarbonate(HCO_3^{-}) Chloride (Cl^{-}) Sulfate(SO_4^{-2})
Decomposition of organic matter in the environment	Ammonium(NH_4^{+}) Hydrogen(H^{+}) Sodium(Na^{+})	Chloride ion (Cl^{-}) Bicarbonate (HCO_3^{-}) Hydroxide(OH^{-}) Nitrite (NO_2^{-}) Nitrate (NO_3) Sulfure (HS^{-}) Organiques radical
Living organisms in the environment		
Municipal, industrial and agricultural sources and other human activities	Inorganic ions including a variety of heavy metals	Inorganic ions, molecules, color
Colloidal suspended gases		
Clay Silicate(SiO_2) Ferric oxide (Fe_2O_3) Aluminium oxide(Al_2O_3 manganese dioxide (MnO_2)	clay, silt, sand and other inorganic soils	Carbondioxide (CO_2)
	Dust, pollen	carbone Dioxyde de (CO_2) Azote (N_2) oxygen (O_2) sulfur dioxide(SO_2)

plant material coloring, organic waste	organic soil (topsoil), organic waste	Ammoniac(NH_3) carbon dioxide (CO_2) hydrogen sulfide (H_2S) Hydrogen gas (H_2) Methane(CH_4) Azote(N_2) Oxygen gas (O_2)
bacteria, algae, viruses, etc.	algae, diatoms, minute animals, fish, etc.	Ammonia (NH_3) Carbon Dioxide (CO_2) Methane(CH_4)
Inorganic and organic solid, coloring matter ,chlorinated organic compound, bacteria ,Worms, viruses	Clay, silt, grit and other inorganic solids, organic compounds, oil, corrosion products; etc.	chlorine gas (Cl_2) sulfur dioxide (SO_2)

BACTERIA CONTAMINATION OF WATER

The bacterial contamination of water in CAR indicate fecal contamination, potentially pathogenic thus microbiological analysis is mainly for detection of total or fecal coliforms. According (Faroq et al., 2008), the presence of E. Coli and coliforms are also considered as an indicator of water pollution with human or animal waste.

In fact, it has been revealed a correspondence between the presence of bacteria, evidence of fecal contamination and the presence pathogenic bacteria. This is particularly the case of coliforms, mainly present in the intestines of warm-blooded animals and humans (SET, 2012). The presence of coliform in raw water indicates the presence of bacteria. The common epidemics diseases such as typhoid or cholera is waterborne (SET, 2012). According to the WHO standard for drinking water: presence of bacterial indicates fecal contamination germs from human or animal origin, such as total coliforms, fecal coliforms and fecal streptococci in a 10ml water (WHO, 1993).

In Central African Republic bacteriological pollution has been considered a potential case as drinking water because it is found naturally in surface water which contain a wide variety of microorganisms. Some of them participate in decomposition of organic matter and recycling nutrients essential to the maintenance of aquatic organisms and in the food chain (Hébert and Légaré 2000).

Others microorganisms from animal manure and human origin may cause serious diseases in humans, including gastroenteritis and skin infections. These indicate that bacteria present in the digestive tracts of warm-blooded animals, such as fecal coliforms and Escherichia coli, are used to change the level of bacterial contamination of the water. In the Central African several studies show bacteriological contamination of drinking water (Mokofio et al., 1991).

The study of (Mokofio et al., 1991) of the bacteriological water quality of the country results to withdrawals several water wells, boreholes and springs in some parts of the city of Bangui in determination of bacteriological contamination. Analysis of the sample showed most part had bacterial pollution are fecal origin. Partial results of bacteriological analyzes are showed in Tables 2 and 3. Presence of bacteria in the sample from the water samples may cause serious human health problems in the long or short term. Water may also serve as shelter for

arthropod vectors or certain parasites in the transmission of diseases such as malaria, yellow fever, filariasis, schistosomiasis, onchocerciasis (Mokofio et al., 1991). But for public health accept that diarrhea is one of the main causes of waterborne disease in Central Africa (Mokofio et al., 1991)

Table 2: Partial results of bacteriological analyzes of water from the well (P) in the district Malimaka (350 ml altitude), (Mokofio et al., 1991)

Origin of water	Depth in (m) envir	Ph	Germ numbers with 100 ml of water				Results interpretation
			coliforms	Escherichia	streptococcus	Clostridium	
P1	10	6	>100	50	22	5	NDW
P2	10	5.5	>100	22	10	3	NDW
P3	10	6	>100	20	20	10	NDW
P4	10	6	>100	50	50	13	NDW
P5	10	6	>100	20	10	10	NDW
P6	10	6	>50	10	5	3	NDW

Legend: NDW = Not Drinking Water

GBWQ = Good Bacteriological Water Quality

Table 3: Partial results of analyzes of water from the well (P), sources (S) and drilling (d) in the Gobongo area (450 m)

Origin of water.	Depth in m	Ph	Germ numbers with 100 ml of water.				Results interpretation
			Coliforme totaux	Escherichia	streptococcus	Clostridium.	
P1	20 m (environ)	6	50	20	0	10	**NDW**
P2	«	6	16	4	15	3	**NDW**
P3	«	6	50	10	20	7	**NDW**
P4	«	5.5	2	0	0	0	**NDW**
P5	«	6	30	10	5	2	**NDW**
S6 – a	«	5.5	20	10	7	1	**NDW**
S6 – b	«	5.5	1	0	0	0	**GBWQ**
S7 – a	«	5.5	50	20	10	5	**NDW**
S7 – b	«	5.5	2	0	0	0	**GBWQ**
F8	50m	6.5	0	0	0	0	**GBWQ**

Légend S w = source of water taken from the collection basin
S b = sample taken directly to the output of the source

NDW = Not Drinking Water
GBWQ = Good Bacteriological Water Quality

The results of the bacteriological analysis of water show that all samples were polluted by the presence of coliforms. They are contaminated with fecal coliform and total coliform. Presence of these pathogens in a volume of 100 ml in water sample indicates that waters are not consistent with the recommended limits and are out of the WHO standards (WHO, 1994).

The government is insisted to teach the population on water treatment at the family level like use of hypochlorite also it need to plan for the expansion of the network of National Water Company in the framework of a comprehensive sanitation policy to avoid the impact of groundwater pollution on the health of CAR.

Table 4. Potential sources of bacterial contamination of water in the Central (Government report 1999)

industrial	Food industries.
Natural	Ru off.
agricultural	Livestock manure: • Discharged to streams (directly or indirectly).Underground storm water drains and fertilized land with animal dopings.
urban	Municipal Wastewater: • untreated • not disinfected; • spills and leads to treatment plants; • sewer overflows. • Runoff (Storm water).
rural	Domestic wastewater unserved buildings (homes and businesses): • direct discharge of untreated sewage; • septic tank overflows; • Resurgence of septic fields. • Run off.

BACTERIOLOGICAL CONTAMINATION SOURCES

In CAR sources of bacteriological contamination of water are manifold. Government report in 1999 shows contaminations from different places which are urban, rural, agricultural, Industrial and natural.

Contamination of waters in CAR are most often caused by permanent risk of exogenous pollution (runoff of rainfall, wastewater discharges, waste fire, infiltration latrines, etc.). According to Desjardins (1997) claimed that the high bacteriological contamination is mostly caused by spills of domestic and agricultural discharges.

Also pollution is caused by intense activities around the water point or a large commercial farm (see photos below). Water pollution consists of spills, runoff, discharges, direct or indirect deposits of organic and inorganic materials may increase water degradation.

Photos below show an overflowing landfill unauthorized on the edges of the river water pollution source in CAR (Rodier, 1996; Faurie et al., 1999).

Photos below shows the sources of non-potable water used by households (Aziz et al., 2005).

PESTICIDES

Pesticides are products (chemical compounds) deliberately released into the environment to fight against living organisms considered harmful (animals, plants, microorganisms). They are mainly used by farmers to fight against animals (insects, rodents) or plants (fungi, weeds) deemed harmful to plantations. The first extensive use of a pesticide is DDT, dates back to the Second World War. In the last four decades, pesticide use has increased almost worldwide .it is to protect crops against insects to achieve higher yields and better quality (Aziz et al., 2008). An estimated quantity 2.5 million tons of pesticides are used globally each year with continuous increases (Pimentel et al., 1995).

In Central Africa, pesticides are used for various purposes; fighting against insects and rodents in households, in agriculture and in the field of public health like repel mosquitoes which cause malaria. However there is a misunderstanding of the dangers arising from the uncontrolled use of pesticides. The levels of water contamination with pesticide residues are quite variable across the country, but many exceeds the limit standard. This situation is further compromised by the high frequency of occurrence of pesticides in water. The excess consumption of water with pesticides for a long period can affect the normal functioning of organs such as the liver, kidneys and can produce clinical effects features such as dyspnea and burning sensation in the urinary tract (Azmir et al., 2006; Khan et al., 2008).

But in CAR, no study has been published on the contamination of pesticides in surface water sources to date. There is no pesticide industries or formulation in Central African Republic, there are private companies approved the import and sale of phyto sanitary products agricultural, household and sanitary. These private companies having received an authorization pursuant to the regulations. Rather they are finished products that are imported especially from parent companies represented at national level according to the government report (2010) .The import chain of pesticides in the country is not well established because it difficult to quantify amount pesticides. Most sellers as shown in the photo below performs

uncontrolled sale, and unauthorized by government. This is favored by the high permeability of borders to many local weekly markets, ignorance by the population of certain products containing extremely dangerous and highly active materials, low cost accessibility of products compared to pesticides authorized by the government and circulating in the country (see table below).

Effort must be done by government authorities to control illegal entries of pesticides in the country but currently there are shortage of skilled worker in these sectors. According to the International Agency for Research on cancer, pesticides are classified as carcinogenic in men which disrupting endocrine and negatively affect the human endocrine systems that can lead to various normal malfunction (EJAZ et al., 2004). The use of pesticides in agriculture and market gardening cannot be avoided, as it is essential to fight against pesticide to get a quality products.

The effect of pesticide are not well clear to CAR people. The effectiveness of these approved pesticide is not completely safe is considered inactive still may become poisonous depending on how it will be applied (Jean-François Bourque, 1999). Farmers, vendors, dealers and workers must be aware of the harmful effects of pesticides and associated problems. They should be well informed on the handling and use of safe pesticides to ensure sustainable development by focusing on the high level of protection of the environment and to humans. For this reason, information campaigns, education and training would be required for all population exposed to pesticides.

Photo: Informal sale of pesticides and fertilizers near market gardening areas kokoro boeing Bangui

CAR growers using pesticides to fight against pests, without wearing protective gears for their health. (Francklin Kamba)

These pesticides are sold on the ground in non-compliant packaging without any indication of the active ingredient without method of use and the precautions. These products are generally exposed beside the different food products like (vegetable oils, grain products and milk

powder, source government report (2010). According to WHO, the main route of pesticide exposure is through diet (90% of the exhibition). water consumption generally represents a minor contribution to dietary exposure to pesticides (Rety, 2012; Anse, 2013).

Table 5: Phytosanitary products RCA outstanding

insecticide (active material and concentration)	**fungicide (active material and concentration)**	**nematicides (active material and concentration)**	**herbicide (active material and concentration)**
Beta cypermethrin 25 g / l Fenoxycarb 500g / l Cypermethrin 50 g / l Cypermethrin 12 g / l Methyl parathion 240g / l Carbanyl 850g / l Endosulfan 350g / l Endosulfan 500g / l Dimethoate 400g / l Thiametoxam 250g / l Chlopyrithos-ethyl 480g / l Cypermethrin 20 g / l Pirimiphos-methyl Malathion 50g / kg Phosphorus aluminum Thiocarb 800g / l	Metalaxyl + 12% copper 60% Copper hydroxide 750g / kg Copper hydroxide 560g / kg Copper hydroxide 53.8% Maneb 80% Mancozeb 80% Thiabendazole 220g / l Difenoconazole 100g / l Cyproconazole 100g / l Chlorothalonil 750g / l Fenaniphos	Caroturan 100 g2 / kg Turbulon 100g / kg Turbulon 150g / kg aldicarb oxamyl Cadusaphos 10%	Diuron 800 g / l Ametryn 500 g / l Glyphosate 360g / l Glyphosate 450g / l Glyphostate 680g / l Metalachlore 300g / l + Atrazine Partaquat 200g / l Ametryn 500g / l Atrazine 900g / l Triclopyr 450g / l Pendimethalin 500g / l Oradiason 400g / l Iolyne 24D + Mexazinone Halaxytap-R oxadiazon Pendimethalin 400g / l Oxadiavayl Nicosulfuron 40g / l + Atrazine 750g / kg Thiamotoxane.

These products are sometimes used indiscriminately for medicinal purposes it is fundamentally a problem of information and awareness. The country is full of resellers and window dressers whose management problem Services responsible for the regulation and control. Indeed, many of them do not meet the profile required by the profession. Empty pesticide containers are used to store, preserve and carry drinks (including water, milk, etc.) and food such as palm oil.

Toxic Metals

Heavy metals are metals form insoluble precipitates with sulfates but in reality the concept of heavy metals is a factual concept, industrial, primarily empirical without precise scientific definition nor universally recognized technique. There is now talk of the Elements advantage Metallic Traces (EMT).Natural water contains impurities (see Table 1), trace elements or heavy metals as it dissolves substances while moving downward as a hydrological cycle (Sarwar et al., 2003). The Heavy metals are considered toxic, while some are trace elements (Cu, Zn, and Fe). This is why the term heavy metal is often applied incorrectly to elements due to their toxicities (ANNE TS et al., 2005). Heavy metals are introduced in both groundwater and surface water through various human activities such as the use of chemicals in agriculture and improper disposal of municipal waste. Many of these metals are considered essential to human

health (Midra et al., 2005). But the overload cause pollution of water result to serious health problems in living organisms including humans. Heavy metals can also contaminate the environment during an industrial activities. For example of pollution "red mud" in Hungary in 2010 that contaminate soils and waterways due to the rupture of a reservoir of an aluminum bauxite plant (letelegramme.com, 2010).

In Central Africa, the heavy metals are present in groundwater and surface water, their concentrations often exceed the maximum permissible concentrations recommended by the WHO for drinking water (Adia Jacques Touchard at al., 2011), and the results of its research are described succinctly in this review as follows:

Iron (Fe) is one of the most abundant metals on earth and it is essential for the normal physiology of the living organism its deficiency or overloading can be harmful to both plants and animals (Anonymous, 2008). Iron concentrations in groundwater CAR respectively vary between 0,13mg / l and 2.4 mg / whereas the WHO suggests maximum iron concentrations is 0.3 mg / l for drinking water. All the drilling of the country contain iron, 50% have higher levels as recommended by WHO standard mainly due to the presence of iron-rich granitic rocks in this area.

According to a study by (Adia et al., 2005), the presence of iron in the waters come from the alteration of the surrounding formations, rich Ferro manganese. Ph conditions and redox potential favorable its solubilization to Fe+2 involve their way into the water. Low doses poses no health problems however, high concentrations of natural water resources can be a possible risk to human health and the environment. compared to the deficit, iron overload or overexposure is a less common condition but it can lead to more serious health problems such as cancer (Beckmann at al., 1999), heart and liver diseases (Milman et al, 2001; Rasmussen et al., 2001;. Yang et al, 1998) diabetes (Perez of Nanclares at al., 2000) as well as diseases neuro - degenerative (Berg .D et al., 2001).

Manganese (Mn) is a natural mineral found in surface waters and in groundwater, but human activities also contribute much to its introduction into waters sources (EPA 2004). In Central African contamination of drinking water by manganese does not pose much problem because its contents vary from 0 to 0,025mg / L, while WHO recommends 0.4 mg / L for drinking water. Manganese (Mn) as Iron (Fe) comes from weathering of rocks, higher doses than 20 mg /L. Manganese is an essential trace element for all life forms (Emsley, 2003) because it regulates many enzymes in the body (Cosgrave and Zhang, 2004). Excessive doses of manganese causes severe disorders in the nervous system with the brain as main target (Cosgrave and Zhang, 2004). According to (Barbeau and al., 1984) manganese in its worst form can lead to permanent neurological disorder with symptoms similar to Parkinson's disease. However, exposure to manganese in water is normally substantially lower than the intake of food (EPA, 2006).

Cadmium (Cd) is a toxic element, safe standard for cadmium concentrations in water according to WHO is 0,003mg / l. In CAR cadmium concentrations in groundwater are above the safe limit set by WHO. This toxic metal can cause acute gastrointestinal problems such as vomiting and diarrhea (Nordberg.GF, 2004). However chronic exposure to cadmium for some time can lead to kidney damage and reproductive problems (Free et al., 1993).
Arsenic (As) is inorganic compounds which are carcinogenic to humans being (AFSSA, 2004.). Epidemiological studies have shown that exposure to arsenic via inhalation or ingestion of contaminated water was responsible for lung, skin and bladder diseases. Other studies also

suggest the existence of an association between exposure to arsenic in drinking water and the development of prostate cancers of the liver and kidney (IARC, 2001).

Arsenic is recognized as a major threat to public health, contamination of water by this metal is a major human health problem in many countries of the world including Argentina, Bangladesh, Chile, China, Mauritania India, Vietnam, Mexico, Nepal, Thailand and the United States of America (Islam-UI-Haque at al., 2007). In CAR lever of arsenic to the groundwater and surface water exceed the standard set by the WHO which is (10 ppb (ug /L). However, the issue of arsenic is a major issue in the country because no specific study on water contamination by arsenic has been published. Still the effect of arsenic is unknown to the public while it contamination is a serious health problem to society. Arsenic at high doses and long exposure may cause melanosis, buffy melanosis, hyperkeratosis, cardiovascular disease, and disease of black feet, neuropathy and cancers (Caussy, 2005).

Zinc (Zn) and copper (Cu) are essential to human health (Solomon et al., 1998), over consumption is harmful to human health (Fosmire et al., 1990). Maximum acceptable concentrations for drinking water is 3mg / l for Zn and 2mg / l Cu. In surface water and groundwater in the country, both heavy metals are usually found below the limit set by the WHO (Adia et al., 2005).

Mercury (Hg) is a chemical element with atomic number 80 it is part of the transition metals and persistent bio accumulative toxin (Weisse et al., 2001). It is introduced into the environment from various natural and human activities (Weiss et al., 2001). According to the WHO standard mercury concentrations in water should not exceed 0.001 mg / l In CAR. Many studies are needed in level of mercury in water in CAR because mercury is a potentially dangerous for human health and environment. They transmitted through food chain. Aquatic environment transform mercury into methyl mercury which is most toxic form (Awafolu et al., 2003). Mercury disrupts the production of neurotransmitters and reduces the significant production of hormones, including thyroid hormone and testosterone in the human body (Fatoki et al., 2003).

Nitrates and Nitrites

Nitrates (No3) are chemical compounds naturally present in low concentrations in the environment, especially in groundwater, surface water and soils. It source from the fixation of atmospheric nitrogen by plants and then from the decomposition of organic material. The nitrogen compounds in the soil are carried by rainwater into rivers and lakes. Nitrites (No2), present in water in low concentrations or in feed are usually result of metabolic processes in the body nitrates (IARC, 2001)

In Central Africa, the concentrations of nitrates in the water is between 0mg / l and 0,35mg / l and lower than WHO standards (Adia Trouchard Jacques et al., 2011). The low concentration of nitrates shows that agricultural activities not intensive and no much use of fertilizer and pesticides. Nitrates are natural compounds that enter the nitrogen cycle, this element is essential for life including the development of .the nitrates found in plants, sometimes can be excessive amounts in drinking water. (The Curier et al., 1998). WHO recommends 3 mg / l for drinking water in the CAR, all drilling analyzed comply with this standard, the average is 0,04mg / l with a variation of 0.01 mg / l 0,38mg / l (Adia et al., 2005) .The relevant epidemiological data on the risk of cancer related to nitrates in water are very rare and do not assess risk accurately (Inca, 2009) .Currently, some studies found an association between the

consumption of water rich in nitrates and the occurrence of cancers, still not yet implemented in the general population (Ward, 2009; ORS, 2007).

Sulfate (SO4) is a salt form by the combination of sulfuric acid with a base. Its concentrations in water (boreholes) in Central Africa vary between 0 mg / 31mg the / l and meet the WHO standard (Mokofio et al., 1991), while WHO recommends 250mg / l for drinking water. The presence of this element in water is generally related to the nature of geological formation and industrial discharges but currently there is no industrial discharges in drilling. Doses of between 1 mg / l and 2mg / l have a mild laxative effect in adults. However higher concentrations can affect gastrointestinal and diarrheal disorders (Desbordes, 2001)

Chromium (Cr) is the metallic chemical element of atomic number 24, is also one of the most common elements in the earth's crust and water. In CAR no study published in water contamination by chromium, but however, chromium is toxic and plays a very important role in the metabolism of carbohydrates in the body (Cefalu et al., 2004).It also cause skin diseases, cancers, irritants and even diseases related to the digestive, excretory, respiratory and reproductive system (Anonymous, 2009).

Fluorine (F) is a chemical element of atomic number 9 and is part of halogens, it is the most electronegative of all. In CAR boreholes Fluoride ranging from 0.2 mg /l and 1. 06mg / l, these concentrations meet the WHO standard for safe drinking water which is 1.5mg / l (Adia Jacques et al., 2011). But excess of fluorine in groundwater cause dental and skeletal fluorosis.

The Aluminium (Al), the chemical element of atomic number 13, WHO report recommend its amount in drinking-water be 0.2 mg / l (Adia Jacques et al., 2011), aluminum content in the groundwater in CAR ranges between 0mg / the 0.09mg / l. Aluminum usually comes from accidental pollution by industries or by dissolving rock and higher doses, it causes color problems.

Chlorine (Cl) is usually used for disinfection of drinking water. It must be analyzed primarily chlorination operation to prevent excessive dose in water. WHO recommends a level of 5 mg / l. Water drillings in CARS have no chlorine problem, doses vary from 0.09 to 1 mg / L.

In the above situation toxic metals in surface water or groundwater in the country show a wide variation in the level of contamination due to their higher concentration against the recommended.

Table 6: Comparison to WHO standards for drinking water according to studies from Central (ADIA Jacques et al., 2011).

Item / substance	Symbol / formula	Concentration normally found in groundwater in CAR	Guidelines set by WHO
Aluminum	Al	0- 0.09mg/l	0.2 mg/l
Ammonium	NH_4^+	No value for lack of studies	No constraints
Antimony	Sb	No value for lack of studies	0.02 mg/l
Arsenic	As	No value for lack of studies	0.01 mg/l

Asbestos			No guideline value
Barium	Ba	No value for lack of studies	0.7 mg/l
Barium	Be	No value for lack of studies	No guideline value
Boron	B	No value for lack of studies	0.5mg/l
Cadmium	Cd	> to the WHO standard	0.003 mg/l
Chlorine	Cl	0.09-1mg/l	No value but one can note a taste from 250 mg / l
Chrome	Cr^{+3}, Cr^{+6}	No value for lack of studies	chrome total : 0.05 mg/l
Couleur			No guideline value
Copper	Cu^{2+}	2mg/l	2 mg/l
Cyanide	CN^{-}	No value for lack of studies	0.07 mg/l
Dissolved Oxygen	O_2	No value for lack of studies	No guideline value
Fluorine	F	0.2 -1.06mg/l	1.5 mg/l
Hardness	mg/l $CaCO_3$	No value for lack of studies	200 ppm
Hydrogen sulphide	H_2S	No value for lack of studies	0.05- 1 mg/L
Iron	Fe	0.13mg/let 2.4mg/l	No guideline value
Lead	Pb	No value for lack of studies	0.01 mg/l
Manganese	Mn	0 – 0.025mg/l	0-4 mg/l
Mercury	Hg	No value for lack of studies	inorganique : 0.006 mg/l
Molybdenum	Mb	No value for lack of studies	0.07 mg/l
Nickel	Ni	No value for lack of studies	0.07 mg/l
Nitrate and nitrite	NO_3, NO_2	No value for lack of studies	50 and 3 mg / l (short term exposure) 0.2 mg / l (long term exposure)
Turbidity			not listed
Ph		The PH varies between 5.40 and 7.1 with an average 6.58	No guideline value but an optimum between 6.5 and 9.5
selenium	Se	No value for lack of studies	0.01 mg/l
Money	Ag	No value for lack of studies	No guideline value
sodium	Na	No value for lack of studies	No guideline value
sulfate	SO_4	0 -31mg/l	500 mg/l
Tin	Sn	No value for lack of studies	No value guide: slightly toxic
TDS			No guide optimum value but below

			1000 mg / l
uranium	U	No value for lack of studies	0.015 mg/l
Zinc	Zn	3mg/l	3 mg/l

The Water Pollution And Its Harmful Effects On Human Health

Water is an important factor for the socioeconomic development of the human being. However poor management can cause disease, pollution or natural disasters. Pollution can be defined in several ways. Water pollution occurs when materials are discharged into the water that degrades the quality. Pollution in the water includes all unnecessary materials that cannot be destroyed by the water naturally or other words any material added to water beyond its capacity to destroy is considered as pollution.

Pollution in certain circumstances caused by the nature itself like when water flows through soil that has a high acidity and corrodes it. Mostly the cause of water pollution are human activities. Water pollution consists of spills, runoff, discharges, direct or indirect deposits of materials of different kinds of materials their physical, biological or bacteriological in surface water, groundwater or sea water, within the limits range. (J,Rodier, 1996:FAURIE et al., 1999).

The Water contamination is a major cause of health problems in human beings. About 2.3 billion people in the world suffer from diseases caused by water pollution (UNESCO, 2003). In developing countries like CAR more than 2.2 million people die each year due to the consumption of unsafe water and inadequate sanitation (UNICEF and WHO, 2000) .The infectious diseases related to water and associated parasite account for 60% of infant mortality in the world (Ullah et al., 2009). For several centuries, waterborne diseases have been responsible for outbreaks of several diseases (typhoid, dysentery and cholera).

Table 7 below shows a list of the pathogens responsible for water borne diseases (Manjour, 1997). In CAR the pollution of drinking water is much caused by municipal waste and wastewater coupled with industrial waste sources of pathogenic bacteria. This waste water caries a large number of pathogens, parasites, bacteria and viruses (MWI, 1987). Pathogenic bacteria and industrial waste which are mainly fed to surface waters by domestic discharges, livestock and industrial activities can infect humans either through drinking water and either by consumption of contaminated food (Manjour, 1997). In CAR there is not a system of disinfection of wastewater and the monitoring of water quality.

According to WHO, 80% most diseases in humans in tropical Africa are most related to waste water. In spite of low average of potable water (30%), the majority of its population is fed from water risk areas. Hence a high prevalence of waterborne diseases such as diarrhea remains a leading cause of mortality. It is very difficult to know exactly the number of people suffering from waterborne diseases in the country due to lack of maintenance of medical records in our hospitals (Report, CAR 1990). UNICEF report in the CAR published in 2010, states that 60% of patients in hospitals suffer from diseases related to water, these diseases include intestinal worms, vomiting, typhoid fever, hepatitis dysentery, and diarrhea E. coli. Lack of effective prevention and control measures contributes to the worsening of this situation (Qasim, 2008). Water pollution is the main cause of illness and death worldwide. According to WHO report, about 4 million children die each year from diarrhea caused by waterborne infection (FAO, 1996).

A potential threat to public health is the occurrence of pesticides in surface and ground water in the country, but few studies have been conducted regarding water contamination by pesticides or pesticide exposure and its adverse effects on human health. Pesticide use has high risk on human health, for example in Pakistan, studies reveal the presence of large amount of pesticide in the blood of humans and their adverse effects on the levels of enzymes in the body (Azmi et al., 2006; Ejaz et al., 2004; Khan et al., 2010). High concentration of nitrates in groundwater main source of water supply of CAR is a major health risk, the human body reduces nitrate to nitrite however nitrites in the blood converts the hemoglobin into met hemoglobin nonfunctional, causing suffocation due to a change of the transport system of the oxygen in the blood cause blue-baby syndrome (Dab, 1990; Fritsch St. Blancat, 1985). Nitrites in the stomach can react with secondary amines to form nitrosamines, which have a recognized carcinogenic effect (Dab 1990; Fritsch St. Blancat, 1985). In Central Africa, studies on pollution of ground and surface water, are most of the lines under university research projects and no publication.

Tableau7: some pathogens can cause infections waterborne according to (Sagik et al., 1987; Edwards, 1992; National Research council, 1998; and Dosso et al., 1998)

	Pathogens	Symptoms
viruses	Hepatitis rotavirus adenovirus enterovirus	hepatitis A Vomiting, diarrhea Respiratory disease, diarrhea, conjunctivitis Paralysis, meningitis, fever
bacteria	Escherichia coli 0157: H7 Helicobacter pylori Leptospira spp Salmonella spp Shigella sp Escherichia coli Yersina enterocoliticia Leginella pneumophila Vibrio cholera	Ulcerative colitis, ulcer and hemoglobin syndrome (HUS) Peptic ulcer, gastric cancers. leptospirosis Typhoid and paratyphoid fevers, acute gastroenteritis Dysentery, gastroenteritis gastroenteritis, diarrhea gastroenteritis Legionellse Cholera, diarrhea
parasite	Entamoeba histolytica Giardia lamblia Cryptosporidium Ascaris Trichuris	diarrhea malabsorption Mild diarrhea, colon ulcer Toxoplasmosis: ganglion, low fever anemia Diarrhea, abdominal pain

Nature And Water Pollution Sources

Several point pollution sources are all once observed worldwide (Environment Canada, 2012). Main sources industrial waste, municipal and domestic waste are discharged into canals, rivers, streams and lakes (Kahloun Majeed et al., 2003). an estimated 2 million tons of water and other effluents are discharged into the world's waters every day, in developing countries including the CAR, the situation is worse or more than 90% of raw sewage and 70 % of untreated industrial wastes are discharged into surface water sources (Anonymous, 2010) .The water pollution is mostly due to human activities (Hammer, 1986).

Populated cities like Bangui pollution of the water table to report water pollution is highly concerned. Castel brewery, slaughterhouses (SEGA), Central African oil mill, old UCATEX textile factory, soap factory (HUSACA) and 8th district directly discharge their waste and sewage into

the river Oubangui (Report by the Government in June 2010). These industries produce hundreds of thousands of waste water containing large amounts of pollutants such as nitrate, nitrite, anions and cations such as Ag+, Na+, K+, Mg+2, Ca+2 ,Cl- ,CO3-2 , HCO3- and toxic metals such as arsenic, iron, lead, mercury, chromium, cadmium, copper, nickel, zinc, cobalt and magnesium (Ullah et al., 2009).

These pollutants from industrial, domestic and municipal do not remain confined waste at the surface of the water but their percolation to soil results in the contamination of groundwater. Waste from human activity are causing pollution of groundwater (Nkhuwa, 2003; Hassoun et al., 2006). Furthermore, the pollution of the ground water is a serious aspect (Laferriere et al., 1996; El Kettani and Azzouzi, 2006). Health risks which are medium and long terms are usually linked to poor physical and chemical quality whereas the short-term risks may result from poor microbiological quality. In some countries, there are wastewater collection systems, normally discharged into the waste water treatment ponds, but in CAR, this system does not exist.

Another source of water pollution is the extensive use of agrochemicals in agriculture. Water contamination with agricultural chemicals has been reported in developed countries such as China (Li Y, Zhang J.1999). Pollution from agricultural sources water is usually related to nitrates or phosphates and pesticides (herbicides, insecticides and fungicides) (Carluer et al., 1996).

Gardeners in CAR use chemicals like fertilizers and pesticides applied on cropland mix with water through the soil and eventually reach natural sources. Numerous pesticides were detected in surface water and groundwater in the country, especially in areas of extensive agricultural practices, various fertilizers applied are not fully utilized by crops, large amounts of leaching water resources resulting in higher concentrations of ammonia, sulfates, phosphates, nitrates and nitrites in the water. These nutrients are responsible for the growth of algae in surface waters and cause eutrophication which poses direct and indirect threats to the environment, some species of these algae produce toxins in the water that are harmful for animals and humans. In addition, some fertilizers contain heavy metals as by-products and their extensive use results in the accumulation of toxic metals in soil and in water (Li, and Wu, 2008).

All these sources of pollution not only contribute to polluted water but also cause widespread bacterial contamination resulting frequency of water-borne diseases. This pollution is most likely to happen in inadequate sanitation infrastructure and garbage collection (see photo below). It is important that the government implements environmental sanitation structures, it also need to place special emphasis on hygiene behavior.

In view of all these pictures, Water pollution is serious environmental problems in CAR because water is an interface between the air and the ground. Water pollution may result to unhygienic condition and compromise public health through water-borne diseases.

Household and municipal waste pollution source in the center of the Central African capital market (source Francklin Kamba)

Photos below show polluted water sources used by households some social activities

5-Ratification of Multilateral Environmental Agreements (MEAs) for the management of the environment by CAR

Long limited to the aspects of fight against desertification and management of natural resources, waste management problem and municipal wastes covered environmental issues overlap increasingly internationally its broadest sense. CAR it is involved in many international agreements in the specific field of the environment and of biodiversity including the following:

- Law No. 94,020 of December 31, 1994 authorizing the ratification of the Convention on Climate Change.
- Act No. 94.01 of 31 December 1994 authorizing the ratification of the Convention on Biological Diversity whose ratifications took place March 15, 1995.

- Law No. 08 002 of 01.01.2008 authorizing the ratification of the basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and their Disposal; biodiversity including among others.
- The Common Regulation on Control of Consumption Substances that Deplete the Ozone Layer in Space CEMAC.
- Law No. 08 003 of 01.01.2008 authorizing the ratification of the Stockholm Convention on Persistent Organic Pollutants (POPS).
- Law No. 08 004 of 01.01.2008 authorizing the Ratification of the Protocol Kyoto on Greenhouse Gases.
- Law No. 08 005 of 01.01.2008 authorizing the Ratification of the Protocol Cartagena on Biosafety.
- Law No. 08 006 of 01.01.2008 authorizing the ratification of Beijing amendments on substances that deplete the ozone layer.
- Law No. 08 007 of 01.01.2008 authorizing the ratification of Copenhagen amendments on Substances that Deplete the Ozone layer.
- Law No. 08 008 of 01.01.2008 authorizing the ratification of the Montreal Amendments on Substances that Deplete the Ozone Layer.
- Law No. 08 009 of 01.01.2008 authorizing the ratification of the London Amendments relating to substances that deplete the ozone layer.

But in reality the country lacked the proper a general law on the protection of the environment, and it was from 2007 that the Environmental Law has been devoted explicitly by the Law No. 07,018 December 2007 on the environment code of the Central African Republic, was the first law of the country for the protection of the environment .this order takes another led to the creation of 3 organization under the following articles:

1. **Art.7: 11:** has created a National Commission for the Environment and Sustainable Development in abbreviated (NCA), ion SLR body. The NCA is a body composed of I State Representatives, Elected Representatives, Local Government and Non-Governmental Organizations. The organization and functioning of the NCA are defined by a decree of the Council of Ministers.
2. **Art. 8:** 11 is created Central Agency for Environment and Sustainable Development, in abbreviated (ACEDD.) The Articles of ACEDD are approved by a Decree of the Council of Ministers.
3. **Art.9:** 11 is created a National Environment in shortens Fund (FNE) for financing activities in the field of the environment, among others fed by taxes and special charges relating to the environment. The Statutes of FNE are approved by a Decree of the Council of Ministers.

Finally, the Law N0 06..001mdu April 12, 2006 on the code of the water in the Central African Republic, this law also led to the creation of four organizations based on the following items:

1. **Art.33:** There shall be a National Water Council and Abstract Sanitation (CONEA) responsible for the supervision of water resources management structures. The CONEA is a body composed of state representatives, elected officials, communities, non-governmental organizations, associations of water users and the specialized agencies. To integrate the effective participation of primary stakeholders, the Council may be decentralized to the watersheds. The organization and functioning of CONEA are defined by a Decree of the Council of Ministers. Art. 34: There shall be a National Agency of Water and Sanitation of the abstract (NAEA). The organization and functioning of the NAEA are fixed by a Decree of the Council of Ministers.
2. **Art.35:** We created a Water Agency Sector Basins abbreviated (ABSE.)

The organization and functioning of the ABSE are fixed by a Decree of the Council of Ministers.

1. **Art.36:** There shall be a Water Sector Regulatory Agency and Sanitation in abbreviated (ARSEA). The organization and functioning of the ARSEA are fixed by a Decree of the Council of Ministers.
2. **Art.37:** There shall be a National Fund for Water and Sanitation in the abstract (FNEA). The organization and functioning of FNEA are fixed by a Decree of the Council of Ministers.

All these laws and policies were designed to prevent pollution of water and provide safety drinking water to the population at affordable costs. Although laws and policies have been approved from time to time, no clear strategy has been developed to date for their implementation.

Similarly, the environmental impact assessment system (EIA) is mandatory but it is rarely followed in the public sector. Environmental courts have been established in all major cities of the country, for the judgment and supervision of environmental issues still are not effective. The main obstacles for implementation are insufficient budgets, poor coordination and poor communication between the responsible authorities such as provincial and local entities. Political interference cannot be excluded from the factors hindering the implementation of environmental laws.

CONCLUSION

Sources of water supply in CAR are highly polluted and impair public health because most pollutants exceed their required range. Water is a major basic need to people of CAR although is highly polluted. Pesticides observed in all water samples from different sources within the country exceed their safety limits. This review clarifies the effect of pollution and its possible sources and how they cause different diseases to human. The shallow aquifers, accessible by sinks, appear highly contaminated with organic substances of human and animal origin. Various human activities, particularly the disposal of municipal waste, domestic and untreated industrial are the main sources of water pollution in the country. Bacteriological pollution for drinking water were the cause of waterborne disease in the country.

Regular surveys should be conducted in different parts of the country to get a clear picture of water-related diseases. Increase in urban population accelerate the problem water pollution. Fighting against water pollution is necessary to be enforced by government and must comply with laws and regulations applicable to the environmental management which will help to minimize the source of water pollution. For better achievement of water management all people starting from family level, private and public sectors must be involved in environment management campaign. It's important to implement training on environmental remediation system which will provide hygienic education to the public.

RECOMMENDATIONS

Water is basic need to human life, its preservation is important to all people. People behavior toward water pollution must changes in order to fight against sources of pollution: The following recommendations are made that can help to control or reduce the problems compromise quality of water in Central Africa.

- Public awareness campaigns should be launched to inform the population about the importance of safe drinking water.

- Campaigns against sewage and other sources of marine pollution.
- There should be enough distance between the wastewater and drinking water supply lines to prevent cross contamination.
- The public should be trained to adapt water management at home.
- There should be a renovation of the old rusty pipes and the water distribution network.
- It is necessary to switch to an intermittent water supply system continuously to avoid widespread contamination from surface water or contaminated wells.
- The need to educate people to treat water at the family level through the use of hypochlorite using a dropper.
- The need to plan for the expansion of the network of National Water Company in the framework of a comprehensive sanitation policy.
- There should be continuous monitoring of the quality of drinking water throughout the country in both rural and urban areas.
- Disposal of industrial waste water should be strictly controlled and all industries should be required to adapt the treatment of their waste water.
- Avoid the use of herbicides, pesticides and artificial fertilizers in gardens and houses and buy organic food.
- The community of farmers and market gardeners have to be well informed on the handling and use of pesticides and proper application of fertilizers to minimize the contribution of agricultural practices on water pollution.
- Requested the public authorities to disclose and reduce questionable chemicals in the water.
- Compost kitchen scraps and garden to reduce water pollution caused by the discharges
- It is necessary to the existence and strict law enforcement, without any compromise on the quality of public drinking water.
- Put pressure on governments so that they act more to protect surface and groundwater from pollution.

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