Ask the Experts – First Edition
GAPWAS

Contamination of water (heavy metals, arsenic and manganese)

(Case Study in Senegal)

Dr. Seydou NIANG
Associate Researcher at the Laboratory of Wastewater Treatment (LATEU)
IFAN Ch.A.Diop, UCAD,Dakar, Senegal

11 November 2021

Presence of heavy metals in water

Introduction Definitions

- Generally defined as natural metallic elements whose density is higher than 5000kg/m^3, sometimes 4000kg/m^3

- Also defined as all elements setting on the periodic table between Cu and Pb,

- Europe proposed the definition maintained for European law and that of its member states: “a heavy metal refers to any compound derived from antimony, arsenic, cadmium, hexavalent chromium, copper, lead, mercury, nickel, selenium, tellurium, thallium and tin, as well as these materials in metallic form, so long as they have been classified as dangerous substances”.;

Presence of heavy metals in water

Introduction Importance

- Naturally present in traces in our environment and massively used in industry.

- Generally emitted through fine particles, transported by the wind and spread out on the soil and water bodies, resulting in the contamination of flora and fauna, thereby transferring them to the food chain.

- Whilst some metals are needed by organisms, others have no biological functions.

- Even though essential, they can be hazardous when in high concentration;

- Toxicity depends not only on the level of concentration, but also on their species formation i.e. the chemical form in which they are present in our environment.

Presence of heavy metals in water

Impact on health

The impact on health depends on its chemical species, its level of concentration, its bioavailability and its transfer to the food chain.

Some do not play any role in maintaining the homeostasis of organisms and are openly hazardous, such as mercury, lead or cadmium,

whilst others are essential (known as trace elements) such as selenium or iron.

Finally, some are neutral and considered biocompatible with organisms, and are therefore used in medicine, such as titanium and gold.

Presence of heavy metals in water

Main heavy metals monitored in potable water

Some heavy metals such as **cadmium, mercury** and **lead** have been the subject of health and environmental research, especially by the EU Water Framework Directive which aims to conserve marine ecosystems. Posing as a hazard to all living things whilst in their oxidised form, the metals do not bring any benefits and are building up in the food chain (bioaccumulation).

One other metal may be added i.e. manganese which does not need to be monitored in potable water (in Quebec), but which was recently recommended for monitoring.

The following metals have also received special attention:

Arsenic
Chromium
Copper

Dangers to Health and Limitations

Dangers related to the presence of As

- Natural arsenic salts are found in all water bodies usually in only small quantities. Majority of the water bodies worldwide contain less than 0.01 mg/litre concentrations of natural arsenic.

- Arsenic contamination of water may also be due to industrial activities such as mining, refining of metal and treatment of wood for construction. Malnutrition may worsen the effects of arsenic contamination in the blood vessels.

- The WHO value guide for arsenic in drinking water is 0.01 mg/litre. This figure is limited to the capacity to measure low concentrations of arsenic in water.

Dangers to Health and Limitations

Dangers related to the presence of As

- Skin diseases
- Cancerous and non-cancerous skin conditions usually occur when exposure is high (>100 µg/L)
- Cancer of the internal organs (lungs and bladder)
- Chronic ingestion even in small quantities (<50 µg/L)
- Cardio-vascular diseases (hypertension, ischemic disease and cardiac arrest)
- High levels of As present in water
- Type 2 diabetes
- Population exposed to large quantities of As

Dangers to Health and Limitations

Dangers related to the presence of mercury

- Mercury is naturally present in the Earth's crust. It is released into the environment through volcanic activity, erosion of rocks and due to human activities. The latter constitute the primary cause of mercury release, coming mainly from coal-fired power plants; domestic use of this mineral for heating and cooking, industrial activities, waste incinerators and mining of mercury, gold and other precious metals.

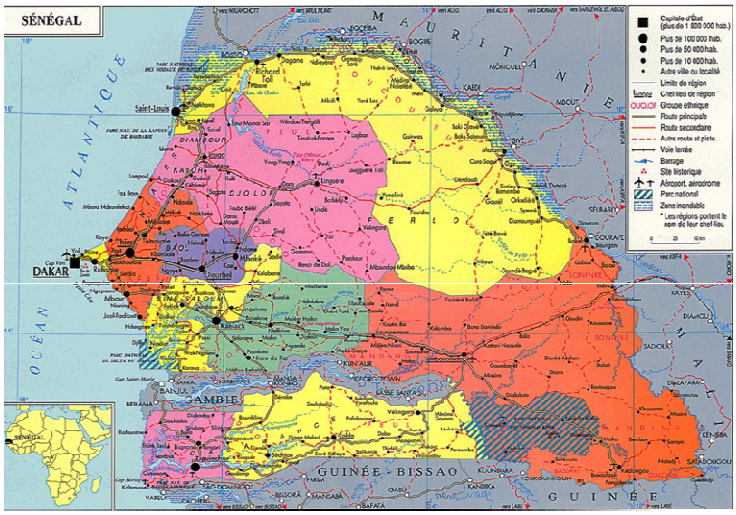
- Once released into the environment, mercury may be transformed by bacteria present in methyl-mercury, which builds up biologically (resulting in larger concentrations than what is present in the environment) in fish and crustaceans. Methyl-mercury also undergoes biomagnification. For example, big predator fish are more likely to contain large quantities of methyl-mercury, having eaten many other smaller fish which have built up mercury by ingesting plankton.

- The WHO value guide for mercury in drinking water is 0.006 mg/litre

Situation of some water sources in Senegal

Senegal is located at the extreme western tip of the African continent into the Atlantic Ocean, at the confluence of Europe, Africa and the Americas, the intersection of major maritime and aviation routes.

Extending over 196,722 km^2, the Senegalese population is almost 12 million inhabitants and an average density of 60 inhabitants per km^2. More than 25% of the population is concentrated in Dakar.



Surface water bodies:

- Senegal, Gambia and Kayanga (Anambé) rivers, the Casamance river and Lake Guiers.

Underground water bodies: (84%)

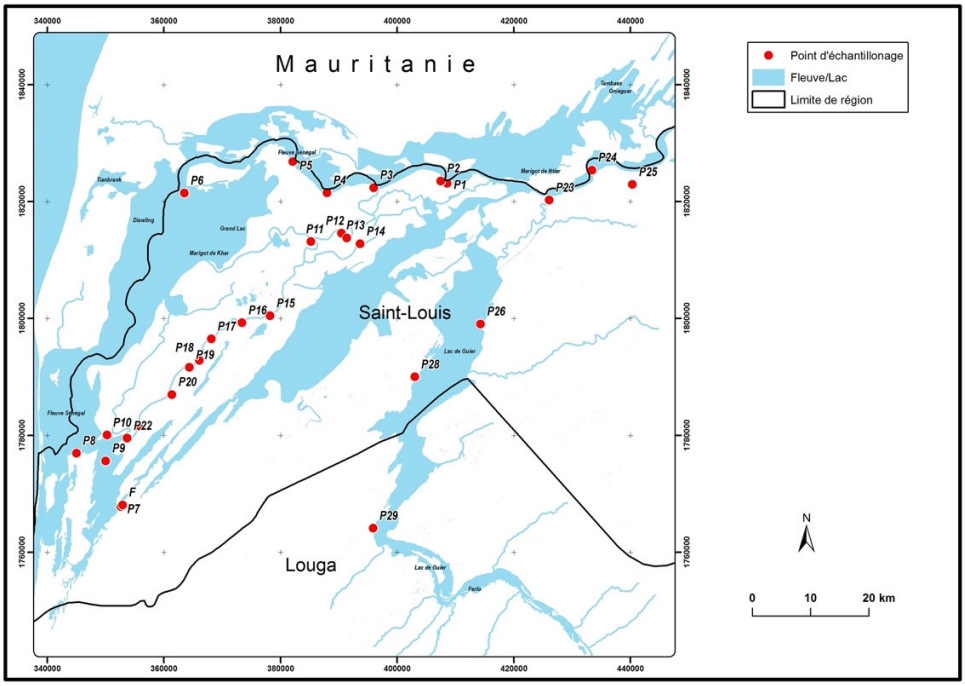
- The superficial aquifer system,
  The intermediate aquifer system,
  The deep aquifer system,
  The base aquifer system

Water resource availability approximately **4750m^3/person/year**

Situation of some water sources in Senegal

The main threat to water resources is heavy metals located in the surface water in the north, where intense food processing activity is developing and south-east with ongoing major mining activities.

Case study at the lower delta of Senegal (2017)



Ref	Al (mg/L)	Cd (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	As (µg/L)	Hg (µg/L)	Se (µg/L)
P1	0.000	9.000	50.000	0.000	63.000	11.000	10.000	7.3	16.100	6.400
P2	0.000	19.000	10.000	60.000	73.000	16.000	20.000	4.3	13.700	6.200
P3	0.000	13.000	70.000	40.000	42.000	6.000	20.000	5.4	15.500	6.300
P4	0.000	10.000	0.000	0.000	71.000	16.000	10.000	4.6	12.600	8.400
P5	0.000	11.000	20.000	20.000	59.000	12.000	20.000	4.7	16.700	4.900
P6	0.000	9.000	10.000	60.000	0.000	5.000	10.000	4.3	17.200	7.200
P7	0.000	7.000	10.000	60.000	0.000	8.000	50.000	4.5	11.400	5.600
P8	0.010	10.000	60.000	50.000	0.000	9.000	10.000	6.2	21.400	5.400

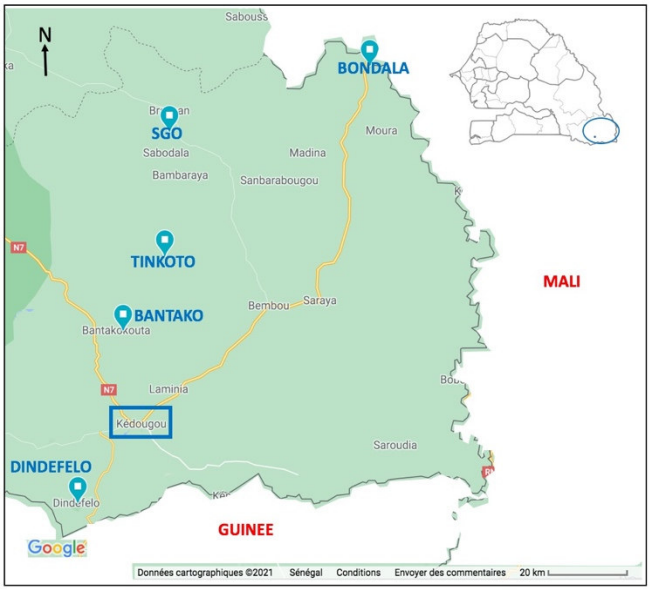
P9	0.000	10.000	40.000	150.000	0.000	5.000	30.000	5.3	14.200	7.100
P10	0.000	13.000	0.000	0.000	21.000	8.000	460.000	5.7	15.400	7.600
P11	0.010	8.000	30.000	70.000	0.000	13.000	10.000	/	/	/
P12	0.000	7.000	50.000	10.000	62.000	6.000	10.000	6.3	12.100	9.300
P13	0.000	13.000	20.000	10.000	64.000	7.000	70.000	5.4	11.200	5.500
P14	0.000	8.000	0.000	0.000	88.000	8.000	10.000	6.2	11.600	8.700
P15	0.000	9.000	10.000	0.000	81.000	9.000	30.000	4.4	10.400	7.500
P16	0.000	8.000	0.000	30.000	79.000	13.000	190.000	7.5	9.700	7.900
P17	0.000	14.000	10.000	150.000	61.000	8.000	10.000	7.8	12.500	7.900
P18	0.000	9.000	30.000	0.000	38.000	5.000	50.000	5.8	9.700	6.400
P19	0.000	8.000	10.000	110.000	63.000	4.000	0.000	5.7	10.200	7.500
P20	0.000	9.000	20.000	10.000	43.000	5.000	150.000	5.6	9.800	7.000
P21	0.000	7.000	10.000	10.000	42.000	10.000	10.000	5.8	10.400	7.300
P22	0.000	8.000	30.000	20.000	38.000	9.000	30.000	6.2	10.000	7.700
P23	0.000	10.000	10.000	0.000	91.000	12.000	0.000	4.3	11.600	7.900
P24	0.000	9.000	10.000	10.000	105.000	12.000	20.000	4.2	13.300	7.500
P25	0.000	11.000	30.000	50.000	4.000	6.000	10.000	5.7	12.800	7.800
P26	0.010	9.000	0.000	30.000	37.000	10.000	10.000	5.7	13.300	7.400
P27	0.010	20.000	0.000	30.000	41.000	7.000	0.000	4.3	14.600	6.800
P28	n.d	9.000	10.000	80.000	30.000	15.000	10.000	4.3	14.600	5.400
P29	n.d	16.000	10.000	40.000	49.000	8.000	10.000	6.2	14.300	7.700
F	n.d	4.000	10.000	60.000	87.000	8.000	10.000	7.4	17.500	8.300
SEQ Water	Nd	5	50	50	20	10	3000	10	1	10
WHO	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd	Nd
DCE	Nd	5	50	50	Nd	50	3000	50	1	10
French	Nd	5	50	50	Nd	50	5000	100	1	10

Standards										

Map of the geographical spread of targeted AEP stations throughout the OLAC network.

Situation of some water sources in Senegal

Case study in the south-east of Senegal (2017)



References	Situation	Cu2+ ((µg/L)	Zn2+ (µg/L)	Mn2+ (µg/L)	Pb2+ (µg/L)	Cd2+ (µg/L)	CN^- (µg/L)	Cr6+ (µg/L)
ON_E1	Falémé river	170	80	0.00	2	0.0	4	0.000
ON_Village	Village borehole	130	130	0.00	7	0.0	6	0.000
N_E1	Wells (15m deep)	270	10	0.00	0	3.4	6	0.000
N_E2	Wells (3m deep)	100	40	0.00	1	3.1	3	0.000
AN_ E1	Gambia river	50	0.00	0.00	0	2.3	-	0.000
AN_E2	Village borehole	70	20	0.00	0	2.0	-	**58**
Gambia	At	10	870	0.000	0	0.9	0.000	**807**

River	Sékoto							
References	SEQ Water	**50**	**3000**	**Nd**	**10**	**5**	Nd	**50**
	WHO	Nd	Nd	**50**	Nd	Nd	**5**	Nd
	DCE	**50**	**3000**		**50**	**5**	**-**	**50**
	French Standards	**50**	**5000**		**50**	**5**	**-**	**50**

Map of the geographical spread of sampling points in the Kédougou area

Challenges with decontamination in Senegal

Detection

Heavy metals in water are often present in traces and the required thresholds in standards are very low. The best measuring instruments are:

- ICP-MS (Inductively coupled plasma mass spectrometer)
- ICP-AES (Inductively coupled plasma atomic emission spectrometer)
- AFS (Atomic fluorescence spectrometer)
- AAS (Atomic absorption spectrometer)

Due to the exorbitant prices in acquiring and maintaining these equipment, few laboratories in West Africa are adequately equipped.

In Senegal for example, it is only recently that analysis of arsenic became possible domestically.

Future prospects

- Set up of facilities to produce and sell equipment at least at the sub-regional level

- Training of human resource for the maintenance of equipment and also to produce the standards

THANK YOU