Cancer Association of South Africa (CANSA)

Fact Sheet and Position Statement on Potable Water and Cancer Risk Reduction

Introduction

Water has always been an important and life-sustaining drink to humans and animals. It is essential to the survival of most other organisms as well. Excluding fat, water composes approximately 70% of the human body by mass. It is a crucial component of various metabolic processes and serves as a solvent for many bodily solutes. Water is the main solvent in biological processes).

[Picture Credit: Drinking Water]

Over large parts of the world, humans have inadequate access to potable water and use sources contaminated with disease vectors, pathogens or unacceptable levels of toxins, carcinogens (cancer causing substances) or suspended solids. Drinking or using such water in food preparation leads to widespread acute and chronic illnesses and is a major cause of death and misery in many countries. Reduction of waterborne diseases is a major public health goal in most developing countries.

[Picture Credit: Safe Water]

Potable Water

The safety and accessibility of potable water (water that is safe enough for drinking and food preparation) are major concerns throughout the world. Health risks may arise from consumption of water contaminated with infectious agents, toxic/harmful chemicals, and radiological hazards.

Improving access to safe drinking-water can result in tangible improvements to health.

Drinking water, also known as potable water or improved drinking water, is water safe enough for drinking and food preparation and is safe enough to be consumed by humans or used with no risk of immediate or long term harm. In most developed countries the water supplied to households, commerce and industry meets drinking water standards, even though only a very small proportion is actually consumed or used in food preparation. Typical uses (for other than potable purposes) include toilet flushing, washing and landscape irrigation.

Disinfection of Drinking water

Disinfection of drinking water kills or removes pathogens from drinking water, reducing health risks. One can disinfect water by adding chemicals, using heat, using ultraviolet (UV) radiation, filtration or using a combination of these methods.

Water pollutants include contamination due to domestic wastes, insecticides and herbicides, food processing waste, pollutants from livestock operations, volatile organic compounds (VOCs), heavy metals, chemical waste, and others. Waterborne diseases caused by polluted drinking water include typhoid, amebiasis, giardiasis, ascariasis, hookworm, etc.

Some drinking water contaminants may be harmful if consumed at certain levels in drinking water while others may be harmless. The presence of contaminants does not necessarily indicate that the water poses a health risk.

The following are general categories of drinking water contaminants and examples of each:

- **Physical** contaminants primarily impact the physical appearance or other physical properties of water. Examples of physical contaminants are sediment or organic material suspended in the water of lakes, rivers and streams from soil erosion.

- **Chemical** contaminants are elements or compounds. These contaminants may be naturally occurring or man-made. Examples of chemical contaminants include nitrogen, bleach, salts, pesticides, metals, toxins produced by bacteria, and human or animal drugs.

- **Biological** contaminants are organisms in water. They are also referred to as microbes or microbiological contaminants. Examples of biological or microbial contaminants include bacteria, viruses, protozoan, and parasites.

- **Radiological** contaminants are chemical elements with an unbalanced number of protons and neutrons resulting in unstable atoms that can emit ionizing radiation. Examples of radiological contaminants include cesium, plutonium and uranium.

Srivastav, A.L., Patel, N. & Chaudhary, V.K. 2020.

"Disinfection means the killing of pathogenic organisms (e.g. bacteria and its spores, viruses, protozoa and their cysts, worms, and larvae) present in water to make it potable for other domestic works. The substances used in the disinfection of water are known as disinfectants. At municipal level, chlorine (Cl_2), chloramines (NH_2Cl, $NHCl_2$), chlorine dioxide (ClO_2), ozone (O_3) and ultraviolet (UV) radiations, are the most commonly used disinfectants. Chlorination, because of its removal efficiency and cost effectiveness, has been widely used as method of disinfection of water. But, disinfection process may add several kinds of disinfection by-products (DBPs) (~600-700 in numbers) in the treated water such as Trihalomethanes (THM), Haloacetic acids (HAA) etc. which are detrimental to the human beings in terms of cytotoxicity, mutagenicity, teratogenicity and carcinogenicity. In water, THMs and HAAs were observed in the range from 0.138 to 458 µg/L and 0.16-136 µg/L, respectively. Thus, several regulations have been specified by world authorities like WHO, USEPA and Bureau of Indian Standard to protect human health. Some techniques have also been developed to remove the DBPs as well as their precursors from the water. The popular techniques of DBPs removals are adsorption, advance oxidation process, coagulation, membrane based filtration, combined approaches etc. The efficiency of adsorption technique was found up to 90% for DBP removal from the water."

Health Effects of Contaminated Water

The US Environmental Protection Agency has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. The contaminants fall into two groups according to the health effects that they cause.

Acute effects occur within hours or days of the time that a person consumes a contaminant. People can suffer acute health effects from almost any contaminant if they are exposed to extraordinarily high levels (as in the case of a spill). In drinking water, microbes, such as bacteria and viruses, are the contaminants with the greatest chance of reaching levels high enough to cause acute health effects.

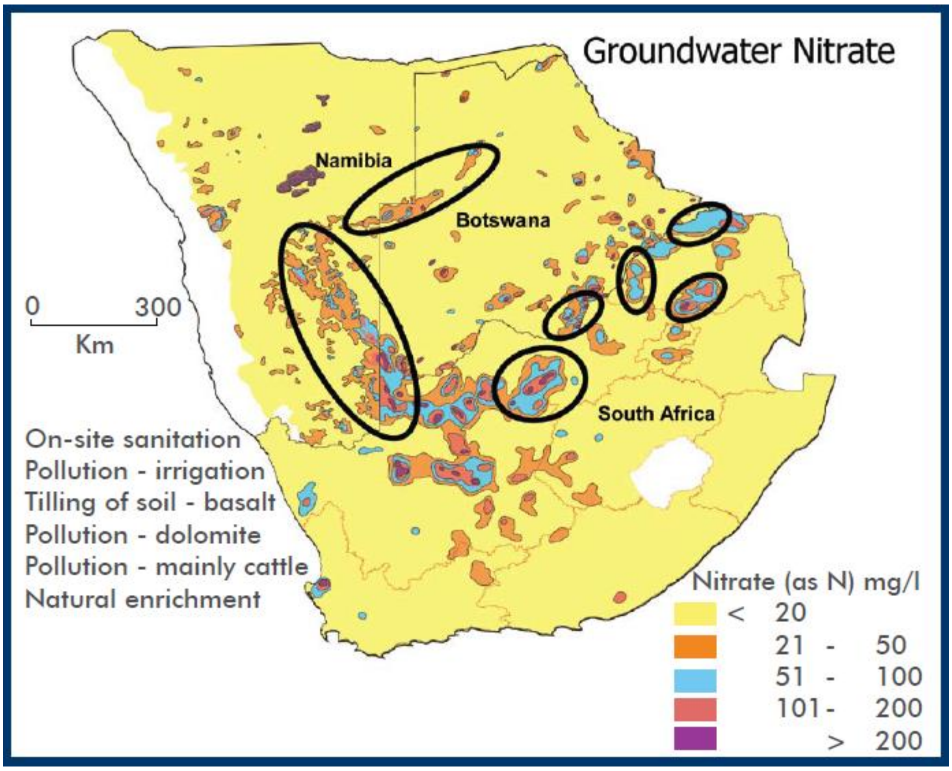
Most people's bodies can fight off these microbial contaminants the way they fight off germs, and these acute contaminants typically don't have permanent effects. Nonetheless, when high enough levels occur, they can make people ill, and can be dangerous or deadly for a person whose immune system is already weakened.

Chronic effects occur after people consume a contaminant at levels over EPA's safety standards over the course of many years. The drinking water contaminants that can have chronic effects include chemicals (such as disinfection by-products, solvents and pesticides), radionuclides (such as radium), and minerals (such as arsenic). Examples of these chronic effects include cancer, liver or kidney problems, or reproductive difficulties.

Nitrate and Nitrite Water Pollution in South Africa

South Africa is a water-scarce country. With periods of prolonged drought and/or decreased rain, dependence on groundwater is increased. This may lead to an increased intake of nitrates and nitrites.

Human activities can greatly increase the amounts of nitrates found. There are often dangerous levels found in South Africa in groundwater (see Groundwater Nitrate Map below), according to recent research done by the CSIR. Sources of Nitrate include fertiliser, animal manure, discharge from sewage facilities, septic tank systems (these remove only half of the nitrate in wastewater, thus increasing groundwater nitrate concentrate). Thus, excessive Nitrate levels are common in rural areas as well as areas where groundwater is sourced to complement water supply during times of drought.



Effects of High Nitrate Levels - Levels above 5 mg/l are undesirable in a water environment as this will disturb the ecosystem. Excessive plant growth will result, especially overgrowth of algae. This can clog streams and dams and use up too much oxygen, causing fish and other species to die.

Water with nitrate contamination has the potential for other contaminants, such as bacteria and pesticides, to reach groundwater along with the contaminant.

Levels above 10 mg/l can be harmful to young babies and pregnant women. High concentrations can cause methoglobinaemia, especially from drinking affected water in formulae (blue baby syndrome). There are also links to longer-term human reproductive and cancer risks.

High nitrate levels are also harmful to ruminant animals. Concentrations over 100 mg/l are toxic.

What needs to be done be done is regular testing for nitrates:

- Wells should be tested due to the high nitrates in groundwater
- Kraal / barnyard runoff, nitrogen fertilisers and septic tanks should be situated further than 30 meters from streams / rivers / dams / wells
- Water contaminated with nitrates can safely be used for washing and household purposes, but not for drinking or cooking
- NOTE: boiling water or adding chlorine will not reduce nitrate levels
- Water treatment methods such as anion exchange and reverse osmosis can be implemented
- Check for other contaminants, as high nitrate levels allow bacteria and pesticides to enter the water, too.

Nitrite was shown to react with nitrosatable compounds in the human stomach to form N-nitroso compounds. Many of these N-nitroso compounds have been found to be carcinogenic in all the animal species tested, although some of the most readily formed compounds, such as N-nitrosoproline, are not carcinogenic in humans.

The Nnitroso compounds carcinogenic in animal species are probably also carcinogenic in humans. However, the data from a number of epidemiological studies are at most only suggestive. The endogenous formation of N-nitroso compounds is also observed in several animal species, if relatively high doses of both nitrite and nitrosatable compounds are administered simultaneously.

Thus, a link between cancer risk and endogenous nitrosation as a result of high intake of nitrate and/or nitrite and nitrosatable compounds is possible.

The Environmental Protection Agency (EPA) has adopted the 10 mg/l standard as the maximum contaminant level (MCL) for nitrate-nitrogen and 1 mg/l for nitrite-nitrogen for regulated public water systems. Subsequent reviews of this standard have not resulted in any changes. However, it is difficult to establish an exact level at which nitrogen concentrations in water are safe or unsafe. The intake of nitrogen from food and other sources also is important and must be considered.

How Much Water Should One Take In?

The average adult needs 30 ml of fluid per kg of body weight per day to maintain hydration. About 60% of this should consist of potable water.

Average body weight is more than 50% water. Without water, one could not maintain a normal body temperature, lubricate one's joints, or get rid of waste through urination, sweat, and bowel movements.

Not getting enough water can lead to dehydration, which can cause muscle weakness and cramping, a lack of coordination, and an increased risk of heat exhaustion and heat stroke. In fact, water is so important that a person could not last more than five days without it.

So how much water does one need? Enough to replace what is lost daily through urination, sweating, and even exhaling.

Need for water increases:

- In warm or hot weather
- With vigorous physical activity, such as exercise or working in the yard
- During bouts of illness, especially if one has a fever, is vomiting, having diarrhoea or coughing a lot

It is often said that one needs to drink eight 8 glasses of water each day. The Institute of Medicine's Food and Nutrition Board recommended that women actually need 2 700ml of water daily, and men need 3 700ml.

It is a good idea to track how much water one drinks for a few days just to get a feel for the amount needed. One can get enough water each day by drinking water and consuming fluids like soup and drinks, along with lots of fruits and vegetables which contain water. Keep in mind that if one is going to do something strenuous, like playing sports or running, one will need extra water before, during, and after.

Water Intake and Cancer Risk Reduction

Studies support the beneficial effect of water drinking on the reduction of cancer risk in addition to other lifestyle factors, such as smoking avoidance or cessation, moderation of alcohol consumption, and treatment or prevention of obesity. Future clinical and epidemiologic studies might help to further define the role of water intake for cancer risk reduction.

Keren, Y., Magnezi, R., Carmon, M. & Amita, Y. 2020.

"Risk and protective factors for breast cancer (BC) include lifestyle, diet, reproduction, and others. Increased risk for colon cancer was linked with low water intake. The link between water consumption and BC was scarcely studied. We investigated the association between water and fluid consumption and the occurrence of BC in a retrospective case–control study in the Shaare Zedek Medical Center, Jerusalem, in 206 women aged 25–65 years (106 with newly diagnosed BC, and 100 controls). A food frequency questionnaire (FFQ), consumption of water, foods, and beverages, lifestyle, and other risk and protective factors were recorded. The age of women in both groups was comparable ((M ± SD) 52.7 ± 9.8 and 50.6 ± 11.4 years, respectively (p = 0.29)). Women with BC consumed 20.2% less water (M ± SD = 5.28 ± 4.2 and 6.62 ± 4.5 cups/day, respectively, p = 0.02) and 14% less total fluids than controls (M ± SD = 2095 ± 937 mL/day and 2431 ± 1087 mL/day, respectively, p = 0.018). Multiple stepwise logistic regression showed that the differences remained significant both for daily water consumption (p = 0.031, CI = 0.462–0.964) and for total daily liquid intake (p = 0.029, CI = 0.938–0.997). Low water and liquids intake as a risk factor for BC may be related to the younger age of our subjects. The effect of age on the potential role of water intake in decreasing BC risk should be investigated."

Dehydration and Cancer Risk

Dehydration happens when a person does not take in enough fluid or loses too much fluid. The body's cells and organs depend on water. Without it, the human body cannot function properly. The water in one's body performs many tasks:

- Transports nutrients and oxygen
- Controls heart rate and blood pressure
- Regulates body temperature
- Lubricates joints
- Protects organs and tissue, including the eyes, ears, and heart
- Creates saliva
- Removes waste and toxins

If receiving cancer treatment, one may be at a higher risk for dehydration due to side effects, such as diarrhoea and vomiting.

Drinking Water Quality
Water quality is a term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for an intended purpose. These characteristics are controlled of influenced by substances, which are either dissolved or suspended in water.

Water quality is a complex subject, in part because water is a complex medium intrinsically tied to the ecology of the Earth. Industrial and commercial activities, for example manufacturing, mining, construction and transport, are major causes of water pollution as are runoff from agricultural areas, urban runoff and discharge of treated and untreated sewage.

According to the World Health Organization (WHO) the quality of drinking-water is a powerful environmental determinant of health. The WHO further states that assurance of drinking-water safety is the foundation for the prevention and control of waterborne diseases.

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking water can result in tangible benefits to health. Every effort should be made to achieve drinking water that is as safe as practicable.

Safe drinking water, as defined by the World Health Organization (WHO) Guidelines, does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages. Those at greatest risk of waterborne disease are infants and young children, people who are debilitated and the elderly, especially when living under unsanitary conditions.

Safe drinking water is required for all usual domestic purposes, including drinking, food preparation and personal hygiene. The WHO Guidelines are applicable to packaged water and ice intended for human consumption. However, water of higher quality may be required for some special purposes, e.g. health institutions, pharmaceutical industry, production of bottled water, etc.

The Cancer Association of South Africa and Bottled Water
Not all bottled water is necessarily safe. Anyone can bottle water in South Africa and sell it so one will really know what one is getting.

CANSA's Position:
The Cancer Association of South Africa (CANSA) advises that individuals should only drink bottled water if it bears the logo of the South African National Bottled Water Association (SANBWA). SANBWA regulates 80% of bottled water in South Africa which is strictly controlled by superb internationally legislated standards. SANBWA water is never untreated tap water.

If bottled correctly, bottled water can last indefinitely. ‘Best before dates’ and ‘batch dates’ are mostly used for stock rotation purposes. CSIR studies found that total microbiological count in bottled water at point of sale is not an indication of quality. Therefore, all tests reported as showing zero *coli forms* and *E.coli* actually indicate that the water is of good quality.

Still mineral water normally bears a two-year expiry date. However, this is used as a lot number for stock rotation purposes. It does not mean the product is sub-standard after this date. The Department of Health, which regulates the safety of bottled natural mineral water, has not set any limitation to the shelf life of bottled water. If stored appropriately still natural mineral water will keep indefinitely. Appropriate conditions for bottled water storage is in a dark, cool, dry area away from any solvents, chemicals or any substance which has strong odours. This applies especially to water in plastic bottles.

Sparkling water on the other hand has a limited shelf life, due to the carbon dioxide which slowly dissipates through the walls of the plastic container and the plastic caps. After a long storage period this water will not have enough sparkle and will be flat. Sparkling water in glass bottles with metal closures have a much longer shelf life than water in plastic bottles. Consumers should also make sure that the bottle still has the factory seal in-tact. Do not accept any product if the seal has been broken, as the quality of the contents can then not be guaranteed.

Following representation and recommendations from the South African National Bottled Water Association (SANBWA) to the National Department of Health, the Department drew up new legislation specific to the bottled water industry.

South Africa's new bottled water legislation defines three classes of water that, if correctly bottled, will be safe, healthy and pleasant tasting.

The first is natural water, sourced from an underground aquifer and bottled at source. The emphasis here is on natural and so no treatment of the water is allowed. Natural mineral water and natural spring water fall into this class.

The second class is waters defined by origin, which includes rain, glacier, mist and spring water. As a general rule these do require antimicrobial treatments, but no treatments are allowed that would alter the chemical composition of the water.

The third class is prepared water, which includes municipal, surface or ground water that has been purified by treatments that change the chemical composition of the water. In the case of municipal water, for instance, previously added chemicals such as fluoride are removed and minerals are added. (SANBWA).

Determinants of Water Quality

The determinants for quality are as follows:

Physico-chemical indicators - are the traditional 'water quality' indicators that most people are familiar with. They include dissolved oxygen, pH, temperature, salinity and nutrients (nitrogen and phosphorus). They also include measures of toxicants such as insecticides, herbicides and metals. Physico-chemical indicators provide information on what is impacting on the system. For example, is it an organic waste that affects dissolved oxygen, or is it some type of toxicant? Although physico-chemical indicators can identify the cause of the problem, they only provide limited information on the extent that pollutants are actually impacting on fauna and flora. To assess this, we need to assess the biological indicators.

Biological indicators **-** are direct measures of the health of the fauna and flora in the waterway. Commonly used biological indicators in freshwater include various measures of macroinvertebrate or fish diversity, benthic algal growth and benthic oxygen demand.

In many aquatic ecosystems, the key influences on aquatic ecosystem health can be factors other than water quality, including habitat degradation and changes to natural flow patterns. Therefore, it is important to include indicators of these factors in monitoring programs.

Perceptions of drinking water - in terms of drinking water quality, user perception is one of the most important things, sometimes exceeding actual quality of water especially when it concerns the quality of drinking water for the user communities (**Sheat**, 1992; **Doria**, 2010).

There are different factors that influence the perception of drinking water quality, including:

- Human sensory perceptions of taste, odour and colour of water are related with mental factors and some extent taste, which is the more important because it may detect water contamination related to chemicals.

- People may perceive risks if they experience health problem caused by water.

Experience with the previous water source status based on its taste, colour and odour change. For example the change in the colour of water from yellowish to bluish may feel that the water is perceived not to be 'good' water (**Doria**, 2010).

Bacteriological parameters - the diseases caused by water related microorganisms can be divided into four main categories:

- Water-borne diseases caused by water that has been contaminated by human, animal or chemical wastes. Examples include cholera, typhoid, meningitis, dysentery, hepatitis and diarrhoea. Diarrhoea is caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water (WHO, 2006). Poor nutrition resulting from frequent attacks of diarrhoea is the primary cause for stunted growth for millions of children in the Developing World (**Gadgil**, 1998).

- Water-related vector diseases. These are diseases transmitted by vectors, such as mosquitoes that breed or live near water. Examples include malaria, yellow fever, dengue fever and filariasis. Malaria causes over 1 million deaths a year alone (WHO, 2006). Stagnant and poorly managed waters provide the breeding grounds for malaria-carrying mosquitoes.

- Water-based diseases. These are caused by parasitic aquatic organisms referred to as helminths and can be transmitted via skin penetration or contact. Examples include Guinea worm disease, filariasis, paragonimiasis, clonorchiasis and schistosomiasis.

- Water-scarce diseases. These diseases flourish in conditions where freshwater is scarce and sanitation is poor. Examples include trachoma and tuberculosis.

Count per 100ml	Risk Category
0	In conformity with WHO Guidelines
1 - 10	Low Risk
11 - 100	Intermediate Risk
101 – 1 000	High Risk
➢ 1 000	Very High Risk

Risk Classification for Thermotolerant Coliforms and *Escherichia Coli* (**Michael, H.** 2006).

Chemical parameters - some of the main chemical parameters that are of a health concern include the following WHO (2004):

- Fluoride causes mottling of teeth and in severe cases can result in crippling skeletal fluorosis.

- The presence of arsenic implicates the risk of cancer and skin lesions.

- Nitrate and nitrite can cause methaemoglobinaemia as well as certain cancers. This arises from excess fertilisers or leaching of wastewater and other organic wastes into surface water.

- Lead can have adverse neurological effects, mainly in areas with acidic waters and the use of lead pipes, fittings and solder.

Secondary concern of the impact of chemical constituents is the effect on distribution and treatment systems that may be implemented to improve the access to a safe water supply. Corrosive properties of constituents can induce structural failure, which can also result in deterioration of the quality of the water and cause additional concerns for health and safety. Due to these concerns, corrosion control is an important aspect of the management of a drinking water system. pH can control the solubility and reaction rates of most metal species involved in corrosion reactions (WHO, 2004).
Iron, lead, copper, brass and nickel can also be used in construction of piping systems (WHO, 2004). Concrete is a composite material consisting of sand, gravel and cement, a binder consisting primarily of calcium silicates, aluminates and some lime (WHO, 2004). Structural deterioration or failure of cement may result from prolonged exposure to aggressive or highly corrosive waters which can result in leaching of metals from the cement into the water.

When ferrous iron oxidizes to ferric iron, it can give a reddish-brown colour to the water, which could be aesthetically displeasing (WHO, 2004). Manganese can cause an undesirable taste as well as staining laundry when levels exceed 0.1 mg/litre. The presence of manganese may also lead to the accumulation of deposits in the piping system (WHO, 2004). There is no health-based guideline value set for iron but for manganese it is four times higher than the acceptable threshold of 0.1 mg/l.

Physical and aesthetic parameters - consumer perception and acceptability of their drinking water quality depends on user sense of taste, odour and appearance (**Sheat** 1992; **Doria** 2010). That is why consumers have differing opinion about the aesthetic values of water quality. Relying on their own senses may lead to avoidance of highly turbid or coloured, but otherwise safe water, in favour of more aesthetically acceptable but potentially unsafe water sources .

Taste and odour can originate from various natural chemical contaminants, biological sources, microbial activity, from corrosion or as a result of water treatment (e.g. chlorination) (WHO, 2004). Colour, cloudiness, particulate matter and visible organisms can also contribute to unacceptability of water sources. These factors can vary for each community and are dependent on local conditions and characteristics. The following lists a number of primary aesthetic indicators that can cause water to be perceived as unacceptable:

- True colour (the colour that remains after any suspended particles have been removed)

- Turbidity (the cloudiness caused by particulate matter present in source water, re suspension of sediment in the distribution system, the presence of inorganic particulate matter in some groundwater or sloughing of bio-film within the distribution system (WHO, 2004).

- Unusual taste, odour and 'feel' problems (usually due to total dissolved solids)

Turbidity is the most important problem for the aesthetic value of water quality. Although it does not necessarily adversely affect human health, it can protect microorganisms from disinfection effects, can stimulate bacterial growth, and indicate problems with treatment processes (WHO, 2004).

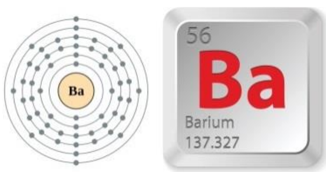
For effective disinfection, median turbidity should be below 0.1 NTU although turbidity of less than 5 NTU is usually acceptable to consumers.

An important operational water quality parameter is pH, although within typical ranges it has no direct impact on consumers. Low pH levels can enhance corrosive characteristics resulting in contamination of drinking-water and adverse effects on its taste and appearance (WHO, 2004). Higher pH levels can lead to calcium carbonate deposition. Careful consideration of pH is necessary to ensure satisfactory water disinfection with chlorine, which requires pH to be less than 8.

Total dissolved solids (TDS) and electrical conductivity (EC) are measures of the total ions in solution and ionic activity of a solution respectively. As TDS and EC increase, the corrosive nature of the water increases (**Addisie**, 2012).

Water Contaminants and Their Possible Health Implications

Barium - There are a number of contaminants that threaten the safety and quality of our nations drinking water, but none is more misunderstood than barium. Barium can suggest the presence of industrial waste, mixing of natural saline and brine waters, salt water intrusion, and other sources.

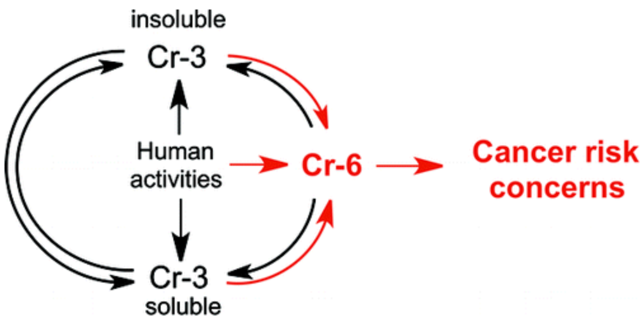


[Picture Credit: Barium]

For drinking water the maximum contaminant level set by the Environmental Protection Agency (EPA) and used by the PADEP is 2.0 mg/L or 2000 ppb. Barium (Ba+2) can cause an increase in blood pressure, gastrointestinal problems, muscle weakness, and affects the nervous and circulatory system.

Barium is a lustrous, machinable metal which exists in nature only in ores containing mixtures of elements. Barium is a naturally occurring alkaline earth metal found in brine water or fluids associated with oil and gas development. In addition, barium can be found in landfill leachate, coal waste, paints, corrosion inhibitors, deicing products (products to prevent snow and ice from bonding to road and walkway surfaces), and high octane fuels. Barium is used to make dyes, fireworks, ceramics, electrical components, and glass, plus it is used as a component in drilling muds.

<u>Chromium</u> - drinking water supplies in many geographic areas contain chromium in the +3 and +6 oxidation states. Public health concerns are centered on the presence of hexavalent Cr that is classified as a known human carcinogen via inhalation. Cr(VI) has high environmental mobility and can originate from anthropogenic and natural sources.



Acidic environments with high organic content promote the reduction of Cr(VI) to nontoxic Cr(III). The opposite process of Cr(VI) formation from Cr(III) also occurs, particularly in the presence of common minerals containing Mn(IV) oxides. Limited epidemiological evidence for Cr(VI) ingestion is suggestive of elevated risks for stomach cancers.

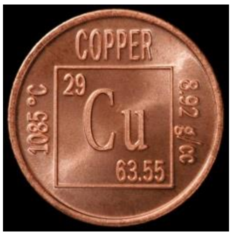
Exposure of animals to Cr(VI) in drinking water induced tumours in the alimentary tract, with linear and supralinear responses in the mouse small intestine. Chromate, the predominant form of Cr(VI) at neutral pH, is taken up by all cells through sulphate channels and is activated non-enzymatically by ubiquitously present ascorbate and small thiols.

The most abundant form of DNA damage induced by Cr(VI) is Cr-DNA adducts, which cause mutations and chromosomal breaks. Emerging evidence points to two-way interactions between DNA damage and epigenetic changes that collectively determine the spectrum of genomic rearrangements and profiles of gene expression in tumours.

Extensive formation of DNA adducts, clear positivity in genotoxicity assays with high predictive values for carcinogenicity, the shape of tumour–dose responses in mice, and a biological signature of mutagenic carcinogens (multispecies, multisite, and trans-sex tumorigenic potency) strongly support the importance of the DNA-reactive mutagenic mechanisms in carcinogenic effects of Cr(VI).

Bioavailability results and kinetic considerations suggest that 10–20% of ingested low-dose Cr(VI) escapes human gastric inactivation. The directly mutagenic mode of action and the incompleteness of gastric detoxification argue against a threshold in low-dose extrapolation of cancer risk for ingested Cr(VI).

Copper – copper in the blood and blood stream exists in two forms: bound to ceruplasmin (85–95%), and the rest "free", loosely bound to albumin and small molecules. Free copper normally reduces oxidative stress, as it is involved in the metabolic elimination of reactive oxygen species, such as with the superoxide radical through Cu-Zn dependent superoxide dismutate (a disproportionation reaction, especially in a biological context, in which oxidised and reduced forms of a chemical species are produced simultaneously [*biochemistry*])



[Picture Credit: Copper]

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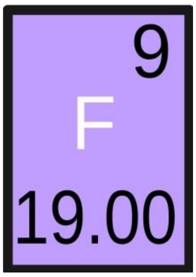
Excessive free copper impairs zinc homeostasis, and vice versa, which in turn impairs antioxidant enzyme function, increasing oxidative stress. Chronically elevated levels of copper intake produces zinc deficiency.

Nutritionally, there is a distinct difference between organic and inorganic copper, according to whether the copper ion is bound to an organic ligand (a molecule that binds to another, usually larger, molecule). Organic copper, like that found in food, is a beneficial micronutrient needed for good health. Inorganic metallic copper, like that found in electrical wire, plumbing pipes, brass fittings, redox water filters, sheet metal, cooking utensils, jewellery and pennies, is a neurotoxic heavy metal linked to physical and psychiatric symptoms on par with mercury and lead.

Fluoride – many individuals have raised questions about the safety and effectiveness of water fluoridation since it first began. Over the years, many studies have looked at the possible link between fluoride and cancer.



[Picture Credit: Fluoride]

More than 50 population-based studies have looked at the potential link between water fluoride levels and cancer. Most of these have not found a strong link to cancer. Just about all of the studies have been retrospective (looking back in time). They have compared, for example, the rates of cancer in a community before and after water fluoridation, or compared cancer rates in communities with lower levels of fluoride in drinking water to those with higher levels (either naturally or due to fluoridation). Some factors are hard to control for in these types of studies (that is, the groups being compared may be different in ways other than just the drinking water), so the conclusions reached by any single study must be looked at with caution.

And there are other issues that make this topic hard to study. For example, if fluoridation is a risk factor, is the type of fluoride used important? Also, is there a specific level of fluoride above which the risk is increased, or a certain amount of time or an age range during which a person would need to be exposed?

Osteosarcoma is a rare cancer. Only about 400 cases are diagnosed in children and teens each year in the United States. This means it can be hard to gather enough cases to do large studies. Smaller studies can usually detect big differences in cancer rates between 2 groups, but they might not be able to detect small differences. If fluoride increased the risk only slightly, it might not be picked up by these types of studies.

More recent studies have compared the rates of osteosarcoma in areas with higher versus lower levels of fluoridation in Great Britain, Ireland, and the United States. These studies have not found an increased risk of osteosarcoma in areas of water fluoridation.

Hard water - in the past five decades or so evidence has been accumulating about an environmental factor, which appears to be influencing mortality, in particular, cardiovascular mortality, and this is the hardness of the drinking water. In addition, several epidemiological investigations have demonstrated the relation between risk for cardiovascular disease, growth retardation, reproductive failure, and other health problems and hardness of drinking water or its content of magnesium and calcium.

[Picture Credit: Hard vs Soft]

In addition, the acidity of the water influences the reabsorption of calcium and magnesium in the renal tubule. Not only, calcium and magnesium, but other constituents also affect different health aspects. There is no evidence of carcinogenicity (**Sengupta**, 2013).

Iron - iron overload usually is caused by the disease, hemochromatosis. It is a genetic disease caused by a change (mutation) in a gene that is important in limiting the absorption of iron from the intestine. If an individual is homozygous for a mutated gene, that is, mutated genes are found on both chromosomes that contain the gene, iron absorption from the intestine is abnormally increased. As a result, iron accumulates in organs within the body. Therefore, in this situation, liver, heart, and pancreatic damage from the iron is highly likely, though not invariable.

[Picture Credit: Iron]

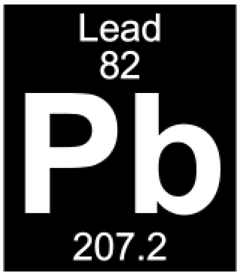
If an individual is heterozygous for a mutated gene, that is, only one of the chromosomes contains a mutated gene and the other chromosome contains a normal gene, there may be an increase in absorption of iron. However, the increase in absorption is less, and there is no clear evidence that organs are damaged.

All individuals with family members with hemochromatosis should have their genes analysed since the mutant genes can be identified in most patients who have them. This is recommended primarily to uncover individuals who are homozygous and, therefore, would benefit by treatment before damage occurs. Genetic testing also identifies individuals who are heterozygous (carriers).

If one undergoes genetic testing, it also may tell one something about one’s child. If one has no mutated genes, his/her child should have no problem with the iron-containing water. That is because his/her child would have normal genes that would assure that the intestine does not absorb excessive iron.

If one has a single gene that is mutated, his/her child has a 50% chance of getting that gene. In this case, testing the child would determine whether or not he or she got the mutated gene and is a carrier. Testing a child would be important also because he or she might get one mutated gene from each parent. In this far-fetched situation, the child would have a high likelihood of developing hemochromatosis.

If an individual has two normal genes, he/she can drink water with high levels of iron. If he/she is heterozygous for a hemochromatosis mutation, he/she probably should drink bottled water rather than water containing high levels of iron, even though this may be unnecessary. Of course, if he/she is homozygous for a hemochromatosis mutation, he/she should drink bottled water rather than water containing high levels of iron. Moreover, he/she should be evaluated by a physician to determine if he/she requires therapy to remove iron from his/her body and if there already has been damage to his/her organs.



Lead – lead is a naturally occurring bluish-gray metal found in small amounts in the earth's crust. Lead can also be found in plants, animals, air, water, dust, and soil. Because it is an element, lead can't be broken down into smaller components.

[Picture Credit: Lead]

It can exist by itself as a metal, but it is more often combined with other elements in a variety of compounds. These compounds are divided into 2 groups:

- Organic lead compounds, where lead is combined primarily with carbon and hydrogen. The lead compounds that were used to make leaded gasoline, tetraethyl lead and tetramethyl lead, are examples of organic lead compounds.
- Inorganic lead compounds, such as lead oxide and lead chloride, are combinations of lead with other elements.

The National Toxicology Program (NTP) is formed from parts of several different US government agencies, including the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA). Exposures that are thought to be carcinogenic are included in the *Report on Carcinogens*, published every few years. The NTP classifies lead and lead compounds as "reasonably anticipated to be human carcinogens”, based on limited evidence from studies in humans and sufficient evidence from studies in laboratory animals.

The International Agency for Research on Cancer (IARC) is part of the World Health Organization (WHO). Its major goal is to identify causes of cancer. The IARC has classified inorganic lead compounds as "probably carcinogenic to humans”, based on limited evidence in humans and sufficient evidence in lab animals. Organic lead compounds are listed as "not classifiable as to their carcinogenicity in humans”, based on inadequate evidence.

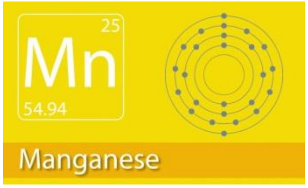
The Environmental Protection Agency (EPA) maintains the Integrated Risk Information System (IRIS), an electronic database that contains information on human health effects from exposure to various substances in the environment. The EPA has classified lead and inorganic lead compounds as "probable human carcinogens”.

Lithium – evidence is accumulating to support the view that variations in cancer incidence are often related to permanent characteristics of the physical environment, namely its climate, geology, soils and water supply.

[Picture Credit: Lithium]

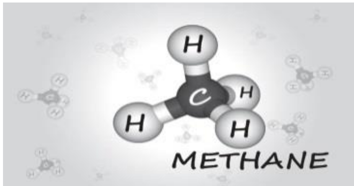
In a Canadian study repeated negative correlations were found to occur, at the national and provincial level, between mortality from cancers of the digestive tract and calcium, magnesium and lithium levels in drinking water.
(Norie & Foster, 1989).

Manganese – No scientific studies are available on the potential carcinogenicity of manganese following inhalation or dermal exposure in humans or experimental animals.



[Picture Credit: Manganese]

The genotoxic potential of manganese in humans is not known (IPCS, 1999). Laboratory evidence for the mutagenicity and genotoxicity of manganese is equivocal. In vitro bacterial gene mutation tests have yielded both positive and negative results, whereas in vitro tests with fungi and mammalian cells have been predominantly positive. In vivo rat studies have been negative, and in vivo mouse studies have been positive (ATSDR, 2000).
Methane – with fracking possibly being allowed in South Africa, contamination of nearby water aquifers could become a problem. Research in the United States showed that directional drilling and hydraulic-fracturing technologies dramatically increased natural-gas extraction.



[Picture Credit: Methane]

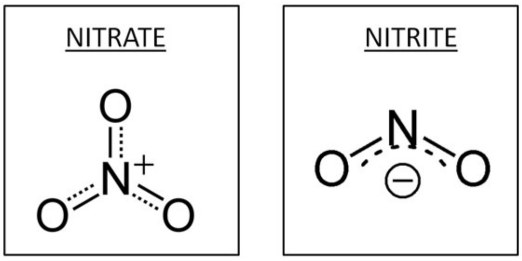
In aquifers overlying the Marcellus and Utica shale formations of northeastern Pennsylvania and upstate New York, the researchers documented systematic evidence for methane contamination of drinking water associated with shale-gas extraction. In active gas-extraction areas (one or more gas wells within 1 km), average and maximum methane concentrations in drinking-water wells increased with proximity to the nearest gas well and were 19.2 and 64 mg CH_4 L^{-1} ($n = 26$), a potential explosion hazard; in contrast, dissolved methane samples in neighbouring non-extraction sites (no gas wells within 1 km) within similar geologic formations and hydrogeologic regimes averaged only 1.1 mg L^{-1} ($P < 0.05$; $n = 34$). Average $\delta^{13}C$-CH_4 values of dissolved methane in shallow groundwater were significantly less negative for active than for non-active sites (-37 ± 7‰ and -54 ± 11‰, respectively; $P < 0.0001$). These $\delta^{13}C$-CH_4 data, coupled with the ratios of methane-to-higher-chain hydrocarbons, and $\delta^{2}H$-CH_4 values, are consistent with deeper thermogenic methane sources such as the Marcellus and Utica shales at the active sites and matched gas geochemistry from gas wells nearby. In contrast, lower-concentration samples from shallow groundwater at non-active sites had isotopic signatures reflecting a more biogenic or mixed biogenic/thermogenic methane source. We found no evidence for contamination of drinking-water samples with deep saline brines or fracturing fluids. We conclude that greater stewardship, data, and—possibly—regulation are needed to ensure the sustainable future of shale-gas extraction and to improve public confidence in its use (**Osborn, et al**., 2011).

[Picture Credit: Methane in tap water following fracking]

Methane in drinking water is not known to be a health hazard when ingested. However, methane can be flammable and explosive when mixed with air, and it can displace oxygen if released into a confined space, resulting in asphyxiation.

Nitrates and Nitrites – contamination of drinking water by nitrate is an evolving public health concern since nitrate can undergo endogenous reduction to nitrite, and nitrosation of nitrites can form N-nitroso compounds, which are potent carcinogens. The researchers conducted an ecologic study to determine whether nitrate levels in drinking water were correlated with non-Hodgkin lymphoma and cancers of the digestive and urinary tracts in an agricultural district (Trnava District; population 237,000) of the Slovak Republic. Routinely collected nitrate data (1975-1995) for villages using public water supplies were computerised, and each village was categorised into low (0-10 mg/L), medium (10.1-20 mg/L), or high (20.1-50 mg/L) average levels of total nitrate in drinking water.

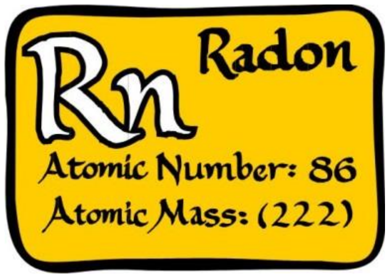
Observed cases of cancer in each of these villages were ascertained through the district cancer registry for the time period 1986-1995. Standardized incidence ratios (SIRs) and 95% confidence intervals (CI) for all cancer and selected cancer sites were calculated by indirect standardization using age- and sex-specific incidence rates from the entire district.



[Picture Credit: Nitrate/Nitrite]

For all cancer in women, SIRs increased from villages with low (SIR=0.87; 95% CI 0.72-0.95) to medium (SIR=1.07; 95% CI 1.00-1.13) to high (SIR=1.14; 1.06-1.22) levels of nitrate (P for trend <0.001); there was a similar trend for all cancer in men from low (SIR=0.90; 95% CI 0.81-0.99) to medium (SIR=1.08, 95% CI 1.02-1.16), but not for high (SIR=0.94; 0.88-1.02), nitrate levels (P for trend <0.001). This pattern in the SIRs (from low to high nitrate level) was also seen for stomach cancer in women (0.81, 0.94, 1.24; P for trend=0.10), colorectal cancer in women (0.64, 1.11, 1.29; P for trend <0.001) and men (0.77, 0.99, 1.07; P for trend=0.051), and non-Hodgkin lymphoma in women (0.45, 0.90, 1.35; P for trend=0.13) and men (0.25, 1.66, and 1.09; P for trend=0.017). There were no associations for kidney or bladder cancer. These ecologic data support the hypothesis that there is a positive association between nitrate in drinking water and non-Hodgkin lymphoma and colorectal cancer.
(**Gulis**, **Czompolyova** & **Cerhan**, 2002).

Radon – radon causes an estimated 14 000 lung cancer deaths in the United States each year. It is the earth's only naturally produced radioactive gas and comes from the breakdown of uranium in soil, rock, and water. One cannot see or smell radon, but it can become a health hazard when it accumulates indoors. It can enter one's home through cracks and openings in the foundation floor and walls. When radon decays and is inhaled into the lungs, it releases energy that can damage the DNA in sensitive lung tissue and cause cancer.



[Picture Credit: Radon]

Radon is a gas produced by the radioactive decay of the element radium. Radioactive decay is a natural, spontaneous process in which an atom of one element decays or breaks down to form another element by losing atomic particles (protons, neutrons, or electrons). When solid radium decays to form radon gas, it loses two protons and two neutrons. These two protons and two neutrons are called an alpha particle, which is a type of radiation. The elements that produce radiation are called radioactive. Radon itself is radioactive because it also decays, losing an alpha particle and forming the element polonium.

Elements that are naturally radioactive include uranium, thorium, carbon, and potassium, as well as radon and radium. Uranium is the first element in a long series of decay that produces radium and radon. Uranium is referred to as the parent element, and radium and radon are called daughters. Radium and radon also form daughter elements as they decay.

The decay of each radioactive element occurs at a very specific rate. How fast an element decays is measured in terms of the element "half-life", or the amount of time for one half of a given amount of the element to decay. Uranium has a half-life of 4.4 billion years, so a 4.4-billion-year-old rock has only half of the uranium with which it started. The half-life of radon is only 3.8 days. If a jar was filled with radon, in 3.8 days only half of the radon would be left. But the newly made daughter products of radon would also be in the jar, including polonium, bismuth, and lead. Polunium is also radioactive - it is this element, which is produced by radon in the air and in people's lungs, that can hurt lung tissue and cause lung cancer.

Radioactivity is commonly measured in picocuries (pCi). This unit of measure is named for the French physicist Marie Curie, who was a pioneer in the research on radioactive elements and their decay. One pCi is equal to the decay of about two radioactive atoms per minute.

Radon is measured in picocuries per liter and written as (pCi/L). One picocurie is one-trillionth of 37 billion disintegrations per second. One curie, named for Marie Curie, the discoverer of metallic radium, is the amount of radiation given off by one gram of radium.

Radon decay products (RDPs) such as polonium(218), lead(214), bismuth(214), and polonium(214), lead(210), bismuth(210), polonium(210) are measured in working levels (WL). A working level is the amount of RDP which normally results when the decay products are in equilibrium (maximum concentration) with 100 picocuries of radon in the air.

RDPs are difficult to measure in a house though, because among other problems, RDPs have a static charge and tend to plate out (stick) to walls, furniture, clothing, dust, smoke, and other objects and substances.

Medical Disclaimer

This Fact Sheet and Position Statement is intended to provide general information only and, as such, should not be considered as a substitute for advice, medically or otherwise, covering any specific situation. Users should seek appropriate advice before taking or refraining from taking any action in reliance on any information contained in this Fact Sheet and Position Statement. So far as permissible by law, the Cancer Association of South Africa (CANSA) does not accept any liability to any person (or his/her dependants/estate/heirs) relating to the use of any information contained in this Fact Sheet and Position Statement.

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