A Report On

ALUMINUM COOKWARE

A MAJOR SOURCE OF TOXIC METAL CONTAMINATION IN BANGLADESH

By Environment and Social Development Organization-ESDO

COOKING WITH ALUMINUM IS DANGEROUS!

According to the World Health Organization, human bodies are capable of properly releasing small amounts of aluminum efficiently, so it's considered safe to ingest 40mg per kilogram of body weight of aluminum per day. Unfortunately, most people are ingesting far more than this.

RISK IS INVOLVED IN MANUFACTURING TOO

In 1984 the International Agency for Research on Cancer concluded: "... certain exposures in the aluminium industry are probably carcinogenic to humans"

2018

Executive Summary

Aluminum cookware is being used for cooking purpose in all over the world. Most of the cookware, used in South Asian countries (including Bangladesh), is made up of aluminum. Cost effectiveness and heat conductance account for its popularity. Despite being harmless in lower concentrations, high aluminum intake results in chronic health effects in the long run.[1]In Bangladesh high demand of aluminum cookware have led to more and more development of aluminum cookware manufacturing industries. Due to its availability and comparatively reasonable price the use of aluminum cookware is now widespread.

To assess the level of metal exposure from aluminum cookware, to determine the demand of this cookware and to identify the level of awareness among the local people about the issue Environment and Social Development Organization-ESDO took the initiative of conducting extensive study in Bangladesh. This report contains how the study was conducted, the analyzed results, an overview of current situation of aluminum cookware used in Bangladesh, the risk associated during manufacture of aluminum cookware, the source and pathway of exposure of aluminum to human, health and environmental impacts, a generalized conclusion and recommendation for further investigation.

Considering the health risk from aluminum published in various study reports, such initiative was taken by ESDO. Aluminum can leach into food, especially when heated. Studies have shown a link between Alzheimer's and aluminum. Aluminum has also been linked to DNA damage and aging of cells, breast and prostate cancer, osteoporosis, and can damage or irritate may other systems.[2]

Most of the aluminum cookware found in local market of Bangladesh is made of scrap metals. During the analyses it was observed that among the metal released from low grade aluminum pots lead content is high. Whether from higher grades higher level of copper are released. Four aluminum cookware samples from the local market of Bangladesh were collected by ESDO team and analyzed in a laboratory of San Francisco which showed an average of 216mg aluminum, 6µg Arsenic, 7.5µg Cadmium, 2µg Lead exposure per serving.

A questionnaire survey was done to assess the level of awareness and the level amount of usage among the local people. For the field survey, Dhaka metropolitan area and adjoining

[1] Semwal, A. D., A. Padmashree, M. A. Khan, G. K. Sharma, and A. S. Bawa. 2006. Leaching of aluminum from utensils during cooking of food. Journal of the Science of Food and Agriculture 86: 2425-2430.
[2]https://embracingimperfect.com/nontoxic/nontoxic-cookware/

Munshiganj, Manikganj, Savar, Gazipur and Tongi area was selected as sampling area. Among 1800 respondents, 800 were from Dhaka Metropolitan Area, and 200 samples each for Munshiganj, Manikganj, Savar, Gazipur and Tongi.

It was found that around 97.56% of the people surveyed (both urban and rural) use aluminum utensils (Cookware, bake ware, cutlery etc.).The level of awareness was found very low, about 4.94% in survey locations

Statement and Significace of the problem

Use of cookware is an inevitable part of our daily life. Clay pots/pans were used as cookware earlier in Bangladesh. With the advancement of technologies many modern cookware such as aluminum cookware, stainless steel, Teflon non-stick cookware etc.have replaced the clay cookware.In Bangladesh cookware manufacturing companies have arose in a large scale.

Figure 1: Aluminum Cookware widely used in Bangladesh for cooking

There are several metal industries who manufacture aluminum, steel, copper cookware and also the non-stick liners. Unfortunately their knowledge on the negative effects of metal cook ware specially aluminum cookware is almost nil. And it is a matter of great concern that almost half of the aluminum workers are women and children. So they are facing the dangerous aspects of aluminum cookware production directly. And, as a country's development can't be accelerated without sound health condition of its inhabitants specially women and children, so it is clear that we are lagging behind. Because we live in a modern industrialized society, heavy metals are found in everyday of existence and they are difficult to avoid entirely. Heavy metal exposure occurs on a daily basis through food, soil, water and

air. But the level of exposure should not exceed its definite tolerable limit. Aluminum cookware poses serious risks to manufacturers, users and to environment and this problem is needed to be addressed.

Metal leaching occurs from aluminum cookware which poses serious threat to human health and environment. Copper, Lead, Arsenic, Aluminum, Mercury, Cadmium etc are the mostly released heavy metal from aluminum cookware. Dr. Jeffrey Weidenhamer, professor of chemistry at Ashland University and an author of the study, tested samples of aluminum cookware made in 10 developing countries and more than one-third of those pose a lead exposure hazard. There are no regulatory standards specific to lead in cookware but the World Health Organization (WHO) and the U.S. Centers for Disease Control and Prevention (CDC) have determined that there is no safe level of exposure to lead. In fact, a scientific advisory board to the CDC recommended this week to lower the blood lead action level for children to 3.5 micrograms per deciliter (ug/dL), underlining the hazard of even low level lead exposures.

"Lead exposure from inexpensive aluminum cookware has the potential to be of much greater public health significance than lead paint or other well-known harmful sources that are common around the world,"-Perry Gottesfeld, executive director of Occupational Knowledge International.[3]

The term toxic metals has been proposed as an alternative since under many definitions nutrient metals such as zinc, copper and molybdenum actually fall under the heading of heavy metals. Metals commonly referred to as heavy metals or toxic metals are detrimental to health for a variety of reasons and unfortunately are prevalent in the environment due in considerable part to the activities of modern society. Individuals may be exposed occupationally or due to factors such as consuming contaminated food and water. Aluminum utensils are harmful because exposure from aluminum utensils not only includes aluminum but also other toxic heavy metals particularly lead, arsenic, cadmium. Severe health problems such as brain disorders (Alzheimer's), breast cancer, bone damage (Osteomalacia)and even death occur due to long term exposure from Aluminum utensils.[4]

Aluminum is quite ubiquitous in nature but its bioavailability is very low. On account of low absorption across the human gastrointestinal tract, aluminum was earlier not considered

[3]http://news.ashland.edu/article/study-conducted-au-warns-lead-and-other-toxic-metals-cookware-made-scrap-metal-contaminates

[4]http://www.ei-resource.org/illness-information/related-conditions/heavy-metal-toxicity/

tohave any adverse effect on human health. However, because of acid rains and its generalized use in water treatment, in cooking utensils and food containers, in cosmetics and medicines, the amount of aluminum uptake by humans have increased and is now of great concern.[5]

Purpose of the study

In Bangladesh, no research on aluminum cookware, its toxic metal content and exposure has been done yet. ESDO has conducted this study setting the following objectives:

- To analyze the country situation of Aluminum cook ware in Bangladesh
- To identify the negative impacts of this cook ware
- To determine the production ratio in Bangladesh
- To identify the number of users in Dhaka and adjoining areas
- To assess the level of awareness among local people
- To assess rules and regulations of toxic heavy metal exposure.

[5]https://www.researchgate.net/publication/233540637_Leaching_of_aluminium_from_cooking_pans_and_food_containers

Review of Related Literature

Heavy Metal and Metal Toxicity

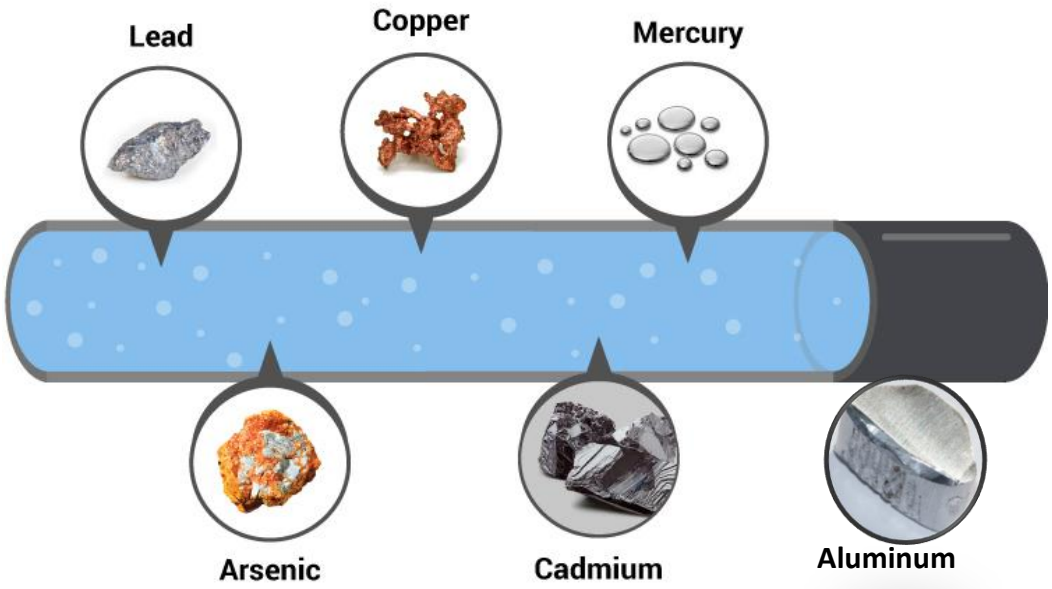

Figure 2: Heavy metal classification

A heavy metal is any of a number of higher atomic weight elements, which has the properties of a metallic substance at room temperature.Living organisms require trace amounts of some heavy metals, including cobalt, copper, manganese, molybdenum, vanadium, strontium, and zinc, but excessive levels can be detrimental to the organism.Other heavy metals such as mercury, lead and cadmium have no known vital or beneficial effect on organisms, and their accumulation over time in the bodies of mammals can cause serious illness.[6]

Metal toxicity or metal poisoning is the toxic effect of certain metals in certain forms and doses on life. Some metals are toxic when they form poisonous soluble compounds. Certain metals have no biological role, i.e. are not essential minerals, or are toxic when in a certain form. In the case of lead, any measurable amount may have negative health effects. Often heavy metals are thought as synonymous, but lighter metals may also be toxic in certain circumstances, such as beryllium and lithium. Not all heavy metals are particularly toxic, and

[6]https://www.sciencedaily.com/terms/heavy_metals.htm

some are essential, such as iron. The definition may also include trace elements when in abnormally high doses may be toxic.[7]

Table 1: Common Heavy Metals[8]

Aluminum	**Cadmium**
Antimony	**Lead**
Arsenic	**Mercury**
Barium	**Nickel**
Bismuth	**Copper**

Aluminum

Figure 3: Metal Aluminum

Aluminum was discovered in 1825 by Hans Oversted of Denmark. Aluminum is the third most abundant element in the Earth's crust, falling behind oxygen and silicon. It is the most abundant metal. It is somewhat surprising, then, that aluminum was not discovered until relatively late in human history. Aluminum occurs naturally only in compounds, never as a pure metal. Removing aluminum from its compounds is quite difficult. An inexpensive method for producing pure aluminum was not developed until 1886.Aluminum is being used in making cookware since 1889.

Pure aluminum is a silvery-white metal with many desirable characteristics.It is light, nontoxic (as the metal), nonmagnetic and nonsparking. It is somewhat decorative and easily formed, machined, and cast. Pure aluminum is soft and lacks strength, but alloys with small amounts of copper, magnesium, silicon, manganese, and other elements have very useful

[7]https://en.wikipedia.org/wiki/Metal_toxicity
[8] http://familywellnesshq.com/heavy-metals-sources-toxicity/

properties. Aluminum is an abundant element in the earth's crust, but it is not found free in nature. Today, aluminum is the most widely used metal in the world after iron. It is used in the manufacture of automobiles, packaging materials, electrical equipment, machinery, cookwareand building construction. Aluminum is also used in beer and soft drink cans and foil because it can be melted and reused, or recycled.[9]Human beings are naturally exposed to relatively large amounts of aluminum from food, water and air.Recently, however, aluminum toxicity has increased precipitously. Today, nearly 80% of those tested for metal toxicity reveal excessively high hair aluminum levels.[10]

Properties of Aluminum

Aluminum has one interesting and very useful property. In moist air, it combines slowly with oxygen to form aluminum oxide. The aluminum oxide forms a very thin, whitish coating on the aluminum metal. The coating prevents the metal from reacting further with oxygen and protects the metal from further corrosion (rusting). It is easy to see the aluminum oxide on aluminum outdoor furniture and unpainted house siding.

Aluminum is a fairly active metal. It reacts with many hot acids. It also reacts with alkalis. An alkali is a chemical with properties opposite those of an acid. Sodium hydroxide (common lye) and limewater are examples of alkalis. It is unusual for an element to react with both acids and alkalis. Such elements are said to be amphoteric. Aluminum reacts with acidsuch as hydrofluoric acid and base such as sodium hydroxide, acting as an acid with a base and a base with an acid, neutralizing the other and producing a salt.

$$Al_2O_3 + 6\ HF \rightarrow 2\ AlF_3 + 3\ H_2O$$

$$Al_2O_3 + 2\ NaOH + 3\ H_2O \rightarrow 2\ NaAl(OH)_4 \text{ (sodium aluminate)}$$

Aluminum also reacts quickly with hot water. In powdered form, it catches fire quickly when exposed to a flame.[11]

Aluminum alloy used in cookware

For the purpose of manufacturing cookware the 3003 aluminum alloy is mostly used. In some cases different heavy metals are used as additives. 3003 aluminum alloy is an alloy in the

[9] http://www.encyclopedia.com/science-and-technology/chemistry/compounds-and-elements/aluminum-alloys
[10]http://www.arltma.com/Articles/AlumToxDoc.htm
[11] http://www.encyclopedia.com/science-and-technology/chemistry/compounds-and-elements/aluminum-alloys

wrought aluminum-manganese family (3000 or 3xxx series). It can be cold worked (but not, unlike some other types of aluminum alloys, heat-treated) to produce tempers with a higher strength but a lower ductility. Like most other aluminum-manganese alloys, 3003 is a general-purpose alloy with moderate strength, good workability, and good corrosion resistance. It is commonly rolled and extruded, but typically not forged. As a wrought alloy, it is not used in casting. It is also commonly used in sheet metal applications such as gutters, downspouts, roofing, and siding.[12]

The alloy composition of 3003 aluminum is[13]:

Aluminum: 96.8 to 99%

Copper: 0.05 to 0.20%

Iron: 0.70% max

Manganese: 1.0 to 1.5%

Silicon: 0.6% max

Zinc: 0.1% max

Residuals: 0.15% max

Commercially pure aluminum (1000-series aluminum, which is 99.9%+ pure) has the highest thermal conductivity of all aluminum alloys, but due to the "orange peel effect" where bonded pure aluminum can form bumps and ridges similar to orange peels due to the nature of its grain, it is not viable to use only pure aluminum as the core of a cladded material.

Aluminum has a somewhat low melting point (e.g., 3003 melts below 1200^0F) and weakens/deforms at even lower temperatures. This is not a problem in normal usage, especially for thick aluminum, but is a potential problem if a forgetful person leaves an aluminum pan on a hot stovetop for long periods of time.[14]Aluminum has an average melting point of 660°C. Melting points for different aluminum alloys are given in Table-1.[15]

[12]Marks' Standard Handbook for Mechanical Engineers, 8th Ed., McGraw Hill, pp. 6-50 to 6-57
[13]http://www.makeitfrom.com/material-properties/3003-AlMn1Cu-3.0517-A93003-Aluminum
[14] https://www.centurylife.org/aluminum-aluminium/
[15] https://www.americanelements.com/meltingpoint.html

Table 2: Melting points for common aluminum alloys

Material	Melting Point (°F)	Melting Point (°C)
Aluminum - Cadmium Alloy	2511	1377
Aluminum - Calcium Alloy	1013	545
Aluminum - Cerium Alloy	1211	655
Aluminum - Copper Alloy	1018	548
Aluminum - Calcium Alloy	1013	545
Aluminum - Germanium Alloy	801	427
Aluminum - Gold Alloy	1056	569
Aluminum - Indium Alloy	1179	637
Aluminum - Iron Alloy	2107	1153
Aluminum - Magnesium Alloy	819	437
Aluminum - Nickel Alloy	2525	1385
Aluminum - Platinum Alloy	2300	1260
Aluminum - Silicon Alloy	1071	577
Aluminum - Thorium Alloy	2259	1237
Aluminum - Zinc Alloy	720	382
Aluminum - Cadmium Alloy	2511	1377
Aluminum	1220	660

Lead is normally present only as a trace element in commercial-purity aluminium but is added at about the 0.5% level with the same amount as bismuth in some alloys (2011 and 6262) to improve machinability.

Dangers of Aluminum Cookware

Aluminum cookware is a long-standing kitchen staple due to its low cost and ability to effectively conduct heat. But decades ago, as autopsy reports found unusually high levels of aluminum in the brains of people with Alzheimer's disease, concern arose over the health risks of this metal including the safety of cooking foods in aluminum cookware. The U.S. Food and Drug Administration (FDA) reports the amount of aluminum that leaches into food from this cookware is much less than the amount naturally present in foods and other consumer products. But because aluminum is a known toxin to the body, the safety of dietary aluminum and this cookware is still a controversial issue with consumers.[16]

Studies have shown that the nature of cook wares, cooking process, storage and processing methods can increase trace metal levels in foods.[17]Cabrera et al. (2003)reported that, the type of cooking utensil used may contribute some considerable amounts of trace metals into our foods by way of leaching in addition to the ingredients used. In our country the most commonly used cooking pots are those made of aluminum and stainless steel. The choice of these pots is because, they are the most popular and economical cookware commonly found in markets in addition to the fact that they are easy to clean, have unique surfaces that cannot crack easily, difficult to rust and high life expectancy.[18]

Metal Leaching From Cookware

The amount of this metal that leaches into food from aluminum cookware and utensils depends on a variety of factors. Acidic foods, such as tomato sauce causes more aluminum to leach from this cookware compared to the effects of lower-acid foods, such as chicken or meat. Prolonged food contact with this metal such as longer cooking or storage times also increases the amount that seeps into the food. In addition, a July 2013 study published in "ISRN Public Health" found that older aluminum pots leach more of this metal into foods compared to new pots and utensils. **A study published in the September 1985 issue of "Journal of Food Protection" estimated food contact with aluminum pans or foil can**

[16] http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware/
[17] Anderson, R. A. 1995. Dietary and metabolic effect in trivalent chromium retention and distribution in rats. Biol. Trace Elem Res. 50:97-108.
[18]Cabrera, C., Lloris, F., Gimenze, R., Olalla, M., Lopez, C., (2003). Mineral content in legumes and nuts: Contribution to the Spanish dietary intake. Sci. Total Environ. 308:1-14.

add an average of 3.5 mg aluminum to the daily diet, an amount the study authors considered insufficient to constitute a health hazard.[19]

Figure 4: Aluminum cookware made from scrap metal releases metals[20]

The amount of this metal that leaches into food from aluminum cookware and utensils depends on a variety of factors. Acidic foods, such as tomato sauce causes more aluminum to leach from this cookware compared to the effects of lower-acid foods, such as chicken or meat. Prolonged food contact with this metal such as longer cooking or storage times also increases the amount that seeps into the food. In addition, a July 2013 study published in "ISRN Public Health" found that older aluminum pots leach more of this metal into foods compared to new pots and utensils.

A study published in the September 1985 issue of "Journal of Food Protection" estimated food contact with aluminum pans or foil can add an average of 3.5 mg aluminum to the daily diet, an amount the study authors considered insufficient to constitute a health hazard.[21]

In another study, levels of trace metals namely: iron (Fe), aluminum (Al), copper (Cu), chromium (Cr) and nickel (Ni) were analyzed spectrophotometrically in rice, beans, yam and

[19]http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware/
[20]https://www.sciencedaily.com/releases/2017/01/170123110345.htm
[21]http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware/

plantain cooked in aluminum and stainless steel pots. These metals were also determined in uncooked rice, beans, yam and plantain which served as Controls. Results obtained indicated that, the lowest concentrations of all the metals analyzed for were recorded in uncooked food items. It was also noticed from results recorded that, the highest mean concentration of Fe (4.45 ± 0.36 mg/kg) was obtained in plantain boiled in stainless steel pot, Al recorded its highest mean level (0.44±0.04mg/kg) in rice cooked in aluminum pot while the highest mean concentration of Cu (7.26 ± 0.06mg/kg) was indicated in beans cooked with aluminum pot.

Chromium recorded the highest mean concentration (0.98 ± 0.04mg/kg) in rice boiled in stainless steel pot whereas; Ni indicated the highest concentration in plantain boiled with stainless steel pot. Results obtained in this study further revealed that, cooking utensils can leach some quantities of trace metals into food during processing, hence resulting in slight increase in the concentration of these metals in processed foods. The study has also shown that, rice and plantain have high potentials of leaching these metals from cook wares examined.[22]

Lead and Cadmium exposure from Aluminum Cookwares

Evidence have been found regarding lead exposure form alluminum cooking pots.Twenty-nine samples of aluminumcookware and utensils manufactured by local artisans in Cameroonwere collectedand analyzed for their potential to release lead during cooking. Source materials for this cookware includedscrap metal such as engine parts, radiators, cans, and construction materials.

The lead content of this cookware isrelatively low(b1000 ppmby X-ray fluorescence), however significant amounts of lead, aswell as aluminumandcadmium were released from many of the samples using dilute acetic acid extractions at boiling and ambienttemperatures. Potential exposures to lead per serving were estimated to be as high as 260 µg, indicating thatsuch cookware can pose a serious health hazard. The researchers conclude that lead, aluminum and cadmium can migratefrom this aluminum cookware during cooking and enter food at levels exceeding recommended public health guidelines. This results support the need

[22]Dan E. U. and Ebong G. A., 2013, IMPACT OF COOKING UTENSILS ON TRACE METAL LEVELS OF PROCESSED FOOD ITEMS; Annals. Food Science and Technology.P-350.

to regulate lead content of materials used to manufacture these pots. Artisanalaluminum cookware may be a major contributor to lead poisoning throughout the developing world.[23]

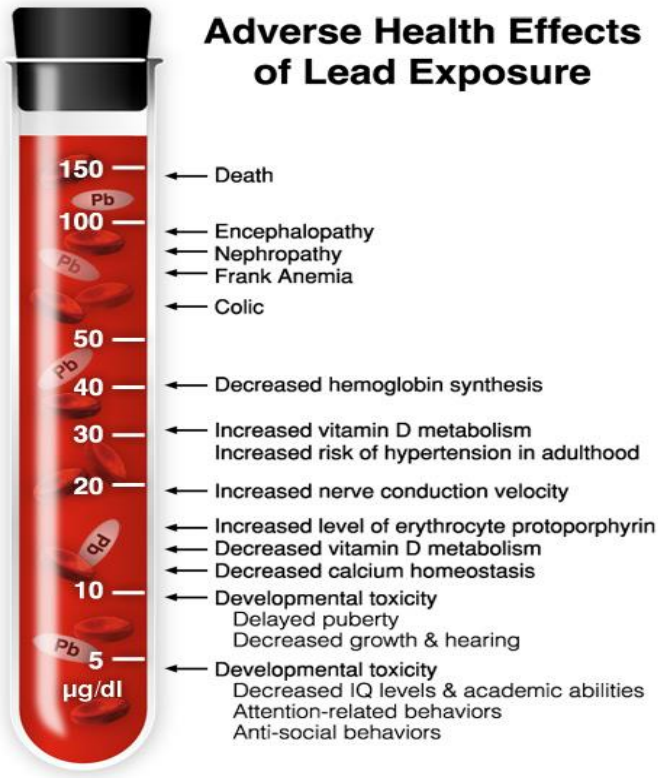

Figure 5: Adeverse Health Effects of Lead Exposure

Effects of Lead on Human Health

Lead accounts for 674,000 deaths annually and is arisk factor for attention-related behaviors, learning disabilities, andcriminal behavior.Lead toxicity in low- and middle-income countriescosts $977 billion annually. There is noidentified threshold for toxicity.[24] The continued prevalence of high blood lead levels inchildren after the phase-out of leaded gasoline is therefore of great concernfrom a public health perspective.Evidence suggests that it may be increasingly toughto identify asingle source of exposure to account for the currentexposure scenarioand to provide relief to millions of exposed individuals.One known source repeatedlycited has been contaminated food.[25]

[23] Jeffrey D. Weidenhamer, Peter A. Kobunski, Gilbert Kuepouo, Rebecca W. Corbin, and Perry Gottesfeld (2014), Lead exposure from aluminum cookware in Cameroon.J. Science of the Total Environment.p-339-347.
[24]Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurstl P, Bellinger DC, et al. Low-level environmental lead exposure and children's intellectual function: an international pooled analysis. Environ Health Perspect 2005;113:894–9.
[25]XieXH, Tan ZW, JiaN, Fan ZY, Zhang SM, Lu YY, et al. Blood lead levels among children aged 0 to 6 years in 16 cities of China, 2004–2008. Chinese Med J Peking 2013;126:2291–5.

Locally-made aluminum cookware is a potential source of lead exposure that has largely been overlooked. This cookware is widely used throughout the developing world.[26] The potential for metals to leach from this type of cookware has been studied previously, but typically with a focus on potential hazards of aluminum.[27]

Heavy Metal Content Varies in Grades

In 2016, an estimated 3.54 million tons of aluminum was recovered from purchased scrap, of which about 58% came from new (manufacturing) scrap and 42% from old scrap (discarded aluminum products), according to the USGS 2017 Aluminum Mineral Commodity Summary.

Manufacturing aluminum from scrap is becoming an increasingly important way to save energy and reduce green-house emissions. The production of secondary aluminum allows businesses to comply with environmental regulations without any loss of quality. However, the addition of scrap into the aluminum production line is a major challenge for the industry. Post-consumer scrap is a mixture of wrought and casting grades; the exact chemical composition, including the presence of contaminants or hazardous elements, is unknown. Without accurate knowledge of the grade and composition of the scrap material being introduced into a manufacturing process, dangerous mishaps can occur.

One example was presented in the study, "Metal exposures from aluminum cookware: An unrecognized public health risk in developing countries," published in the February 2017 issue of Science of the Total Environment. As summarized in ScienceDaily.com, researchers at Ashland University and Occupational Knowledge International tested 42 samples of aluminum cookware made from recycled scrap metal, including auto and computer parts, cans, and other industrial debris, in 10 developing countries and found more than one-third contained lead. The cookware also released significant levels of aluminum, arsenic and cadmium. The World Health Organization (WHO) and the U.S. Centers for Disease Control and Prevention (CDC) have determined that there is no safe level of exposure to lead.[28]

[26]Al Juhaiman, L.A., 2012. Estimating aluminum leaching from aluminum cookware in different vegetable extracts. Int. J. Electrochem. Sci. 7, 7283–7294.
[27]Mohammad, F., Al Zubaidy, E., Bassioni, G., 2011. Effect of aluminum leaching process of cooking wares on food. Int. J. Electrochem. Sci. 6, 222–230.
[28]https://www.thermofisher.com/blog/metals/lead-found-in-pots-made-from-recycled-scrap-metal/

Health Effects of Aluminum

- Aluminum is a **potent neurotoxin**. It may contribute to poor memory and concentration and mood disorders such as depression and anxiety by interfering with communication between brain cells.
- Higher aluminum levels are linked with increased production of beta-amyloid proteins and increased risk of **Alzheimer's disease**.
- Aluminum is known to be genotoxic - it damages genetic material. It has been strongly linked to breast cancer (especially from antiperspirants) due both to the damage it exerts on DNA and because it interferes with the function of estrogen.
- Aluminum also interferes with key energy producing reactions within every cell and thus can be a significant contributor to symptoms of **chronic fatigue and general malaise**.[29]
- It is particularly poisonous to the nervous system with a range of symptoms that can include disturbed **sleep, nervousness, emotional instability, memory loss, headaches, and impaired intellect.**
- It can **stop the body's ability to digest and make use of calcium, phosphorus and fluoride**. This prevents bone growth and reduces bone density. Aluminum can also cause conditions which actually **force calcium out of the bones**. Either of these situations can bring on weakness and deformation in the bone structure with crippling effects.
- A review of the medical literature found that high use of aluminum-containing antacids is often a cause of **osteomalacia** (softening of the bones) and fractures, even in the relatively young (40-50 age group).[30]

[29]Mailloux RJ Hamel R and Appanna VD (2006) Aluminum toxicity elicits a dysfunctional TCA cycle and succinate accumulation in hepatocytes Journal of Biochemical and Molecular Toxicology 20(4):198-208
[30]http://www.drpepi.com/aluminum-poisoning.php

- The sever diseases associated with aluminium toxicity are-

Amyotrophic lateral sclerosis
Anemia
Hemolysis
Leukocytosis
Porphyria
Colitis
Dental Cavities
Hypoparathyroidism
kidney dysfunction
liver disfunction
Neuromuscular disorders
Osteomalacia
Parkinson's Disease
Ulcers

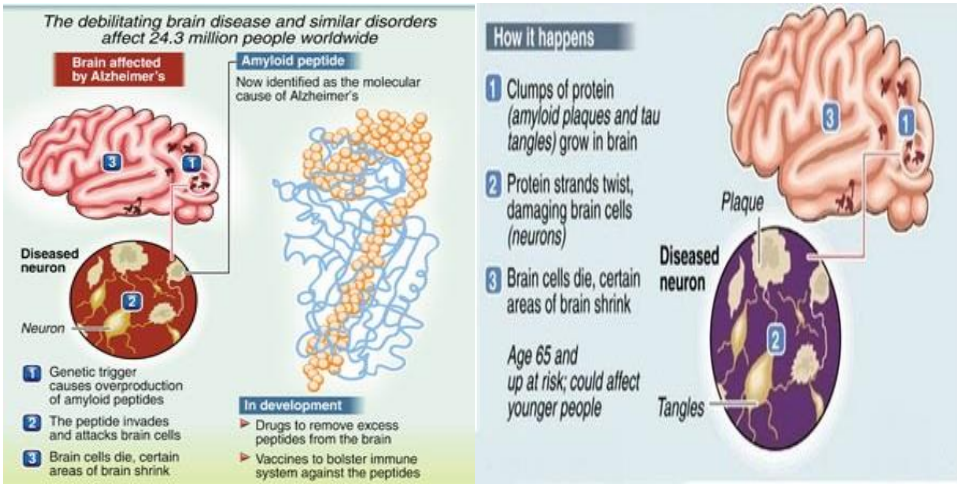

Figure 6: Brain disorder due to Alzheimer's disease[31]

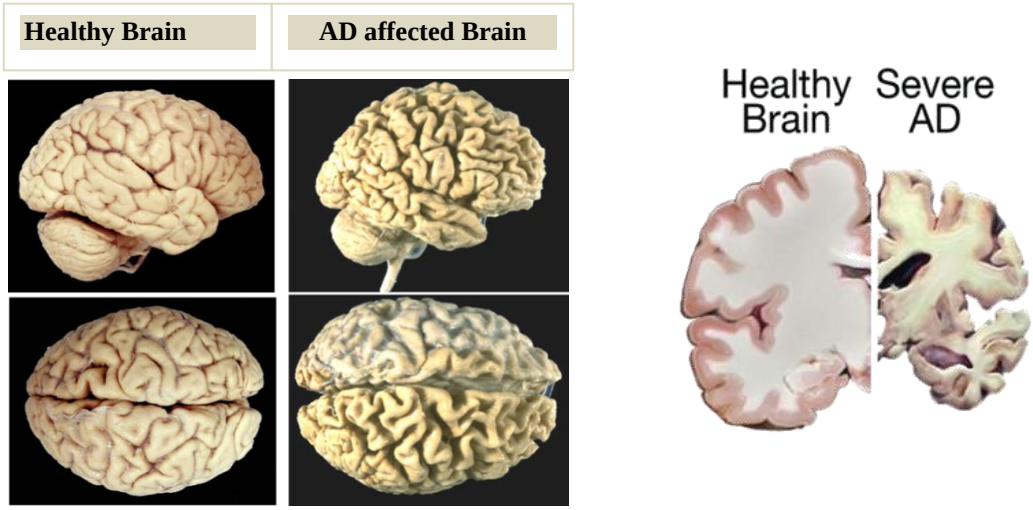

Figure 7: Healthy Brain Vs Alzheimer's Affected Brain[32]

[31]***https://media.licdn.com/mpr/mpr/shrinknp_800_800/p/6/005/0a4/21d/2b3a1b6.jpg***
[32]ttps://classconnection.s3.amazonaws.com/403/flashcards/3629403/png/atrophy-14249AC1AD912A56462.png

The World Health Organization has recommended that aluminum levels in community water supplies should not exceed 0.2 mg/L. This is the same level allowed in bottled water which is regulated by the U.S. Food and Drug Administration. In January 2011, Wisconsin adopted a standard of 0.2 mg/L for aluminum levels in groundwater. Water that contains more than 0.2 mg aluminum per liter should not be used for drinking water or to prepare beverages or infant formula. It is safe to use this water for other purposes such as bathing, showering, food preparation, and household chores.

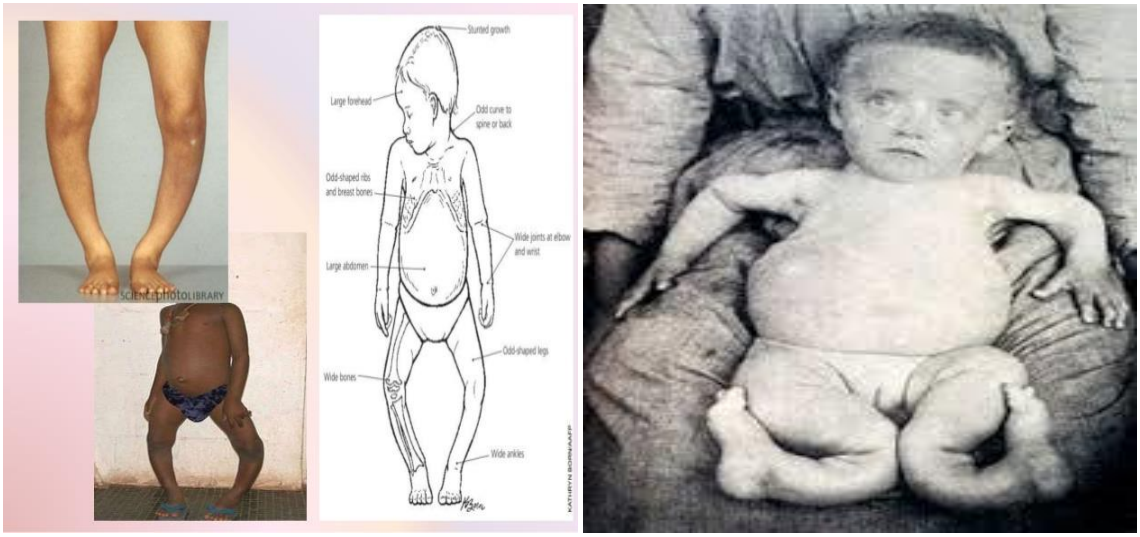

Figure 8: Osteomalacia in children[33]

While there is no evidence to suggest that ingestion of foods or beverages that naturally contain tracesof aluminum is harmful, several investigators have recently reported cases in which short-termexposures to high aluminum levels in drinking water or dialysis fluid resulted in clinical diagnoses ofdementia. In addition to these reports, researchers in France and Canada have reported slightly higherrates of Alzheimer's Disease among residents of communities that had elevated aluminum levels intheir water supplies. Infants and older people whosuffer from diseases that affect kidney or liver function may be especially sensitive to the effects ofingested aluminum.We are unaware of any studies that have evaluated aluminum exposure in infants or young children.[34]

[33]https://image.slidesharecdn.com/physiologyofbone2-140920220444-phpapp02/95/physiology-of-bone-2-31-638.jpg?cb=1411250709
[34]https://www.dhs.wisconsin.gov/publications/p0/p00261.pdf

Environmental Impact of Aluminum

Throughout the processes of Aluminum ore mining, aluminum extraction, aluminum alloy production, production of aluminum cookware, pots, cans etc. and its use and disposal it contributes largely in the pollution of environment.

- Mining ores is a dirty destructive process and bauxite mining is no different.The majority of bauxite is surface mined. This requires stripping everything off the surface of the land: trees, shrubs, plants, flowers, animals, top soil, and even rocks to expose the bauxite. Giant excavators dig up the bauxite and huge trucks, rail cars, or conveyor systems transport it to a refining plant.
- Since bauxite mainly occurs in tropical areas, clearing the land contributes to rainforest deforestation and loss of biodiversity. Bare land does not retain rainfall and causes erosion, sedimentation build up in rivers and streams, drinking water pollution, and farmland degradation. An ecosystem develops over hundreds, thousands, or even tens of thousands of years. Post-mining attempts at remediation can never replicate or replace what was destroyed.
- During Bauxite refining the filtering process leaves behind a toxic sludge, commonly called red mud or red sludge. Red mud is highly caustic and may contain radioactive materials and heavy metals. The high pH of red mud is strong enough to kill plants, animals, and burn airways if breathed in. Eventually, the red mud dries out, is buried under a layer of soil, and becomes a toxic landfill. Smelting aluminum emits greenhouse gases and toxins including carbon dioxide, fluoride, sulphur dioxide, dust, polycyclic aromatic hydrocarbon, and toxic effluents.
- Mining and refining bauxite and smelting aluminum is immensely energy intensive, uses large amounts of water, and generates air, water, and soil pollution. Making aluminum is harmful to the environment and the people who live near mining, refining, or smelting operations. Some companies involved in the aluminum industry are working to increase energy efficiency, decrease pollution, remediate mining areas, and reduce impacts to local communities, but making aluminum is not a benign process.[35]
- Aluminum is a widely used metal in manufacturing industries so air pollution from aluminum plants is substantial. One study found people living close to such a plant were more than 4 times more likely to be admitted to hospital and have increased risk of

[35]http://greengroundswell.com/aluminum-beverage-cans-environmental-impact/2014/07/17/

suffering aluminum related health effects than those living far from such sources industrial pollution.[36]

Other Uses of Aluminum and Sources of Exposure

Aluminum is used extensively in various ways:

- Aluminum can be found in food-related products including pots and pans; storage containers, such as beverage cans; and foil.
- Aluminum is found in numerous foods and beverages including fruits and vegetables, beer and wine, seasonings, flour, cereals, nuts, dairy products, baby formulas, and honey. Typically, adults ingest 7 to 9 milligrams of aluminum per day.
- Aluminum is found in health products including antacids, buffered aspirin, antiperspirants and some vaccines.

Food

Some foods such as tea and cereal crops contain naturally occurring aluminum but the greater proportion of aluminum in food comes from additives. Many food additives approved for use in the US and Europe containaluminum and these are ubiquitous in processed foods. For example, sodium aluminum phosphate is a common raising agent in baked goods, while processed cheese is also high in aluminum.[37]

Reaction of Food with Aluminum

Aluminum is a popular metal in cookware because it's lightweight and good at conducting heat. One downside to aluminum is its softness. To give it more strength, aluminum is often alloyed with other metals, such as magnesium, copper or bronze. An additional problem with aluminum is that it reacts with certain foods and can change their flavor.

Fruits

Fruits can cause oxidation because of their acid content; for example, apples contain malic acid, and citrus fruits are high in citric acid. Both can react with uncoated aluminum. Aluminum reacts with citric acid and forms aluminum citrate. Citric acid is atriproticacid : $C_3H_4OH(COOH)_3$. the reaction is as follows[38]-

[36]Petrela J Câmara VM Kennedy G Bouyahi B Zayed J (2001) Health effects of residential exposure to aluminum plant air pollution Archives of Environmental Health 56(5):456-60
[37]Saiyed SM and Yokel RA (2005).Aluminium content of some foods and food products in the USA, with aluminium food additives Food Additives & Contaminants 22(3):234-44
[38]https://answers.yahoo.com/question/index?qid=20110216094851AA17Q1r

$$2\ C3H4OH(COOH)_3 + 2\ Al = 2C_3H_4OH(COO)_3Al + 3\ H_2$$

$$2\ C_3H_4OH(COO\text{-})_3(aq)+6H\text{-}(aq)+2\ Al(s) = 2C_3H_4OH(COO\text{-})_3(aq)+2Al\ _3+(aq) + 3H_2(g)$$

Aluminum acetate affects kidney and liver as well as the reproductive system. The National Toxicology Program (NTP) has planned toxicity/carcinogenicity testing for aluminum citrate. The rationalefor testing is that aluminum is listed by the EPA as a drinking water contaminant with a high health research priority.[39]

Tomato Sauce

Tomato sauce and other tomato products react with aluminum because of their acidic reaction, and acids don't mix well with aluminum. Highly acidic foods cause oxidation, which can darken the aluminum pan and alter the taste of the food. We can avoid this oxidation problem if we choose cookware that has aluminum on the inside with an outer coating of stainless steel. If we want to spend a little more money, buy anodized aluminum cookware.

Vegetables

Avoid cooking several types of vegetables in aluminum. Rhubarb, sauerkraut, asparagus and artichokes are some of the veggies may react with aluminum. Again, the acid in these foods reacts with the aluminum.

Vinegar

If you like cooking with vinegar, you might want to consider cooking in something other than uncoated aluminum. The amount of acetic acid in vinegars can vary, but it's especially high in pickling vinegars.

Eggs

To enjoy scrambling eggs or flipping omelets, an aluminum pan may not be the best choice. Egg yolks may cause oxidation problems, and the minute amounts of aluminum released into the eggs may give them an off taste. Sometimes the color of the egg turns into green just because of the reaction of iron from the pan and egg.

[39]National Toxicology Program. Salmonella study overview with aluminum citrate. Study A14572. http://ntpapps.niehs.nih.gov/ntp_tox/index.cfm?fuseaction=salmonella.salmonellaData&endpointlist=SA&study%5Fno=A14572 &cas%5Fno=31142%2D56%2D0&activetab=detail. 2003. Date Accessed 4-19-2011.

Salty Foods

Foods high in salt may react with aluminum. In fact, makers of aluminum cookware and bake ware warn against storing salty foods in uncoated aluminum products. The salt can cause pitting of the aluminum surface over time. Highly acidic foods can lead to pitting too.[40]

The Joint Food and Agriculture Organization / World Health Organization Expert Committee on Food Additives (JECFA) has re-evaluated the safety of aluminum in June 2006 and concluded that aluminum compounds have the potential to affect the reproductive and developing nervous system in experimental animals at doses lower than those used in establishing the previous safety reference and hence reduced the safety reference to a lower value (i.e. the Provisional Tolerable Weekly Intake (PTWI)was reduced to 1 mg/kg body weight (by weight). Following the setting of a lowered PTWI, JECFA has recommended Codex that the provisions for aluminium-containing food additives included in the Codex General Standard for Food Additives (GSFA) should be compatible with the newly established7safety reference for aluminum compounds. JECFA also confirmed that dietary exposure, particularly through foods containing aluminum-containing food additives, was found to represent the major route of aluminum exposure for the general population.[41]

Food Packaging

Aluminum foil is highly used in packaging or wrapping foods. Studies have also shown processed foods and soft drinks packaged in aluminum cans, trays and wrappers canbe contaminated with considerable amounts of aluminum; this is especially true of acidic and salty foods e.g. tomato pasta sauce.[42]

A 2012 study published in the International Journal of Electrochemical Science investigated the amount of aluminum that leaches into food cooked with foil. The amount varied based on factors such as temperature and acidity (fish and tomatoes are highly acidic), but the findings showed conclusively that aluminum foil does leach into food cooked in foil. “Aluminum foil used in cooking provides an easy channel for the metal to enter the human body,” the study authors wrote. “The increase in cooking temperature causes more leaching. The leaching is

[40]http://www.livestrong.com/article/284386-foods-that-will-react-with-aluminum-magnesium-pans/
[41]WHO. Evaluation of certain food additives and contaminants : sixty-seventh report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical Report Series 940. Geneva: WHO; 2007.
[42]Rajwanshi P Singh V Gupta MK Shrivastav R Subramanian V Prakash S Dass S (1999) Aluminum leaching from surrogate aluminum food containers under different pH and fluoride concentration Bulletin of Envionmental Contamination and Toxicology 63(2):271-6

also highly dependent on the pH value of the food solution, salt, and spices added to the food solutions."

Ghada Bassioni, Associate Professor and Head of the Chemistry Division at Ain Shams University, Cairo, conducted research with a group of colleagues that explored the use of aluminum for cooking and preparing food particularly at high temperatures. "The acidity of the food would enhance further leaching of aluminum into the meal," she said, adding: "How aluminum will actually harm your body depends on many factors like your overall well-being and consequently how much your body can handle accumulation of it in relation to the allowable dosages set by the World Health Organization."[43]

Aluminum Cookware

There are a wide variety of examples of aluminum utensils, which divide roughly into three groups: eating utensils, stirring utensils and cooking utensils. Each of these utensils has its own specific purpose and works in tandem with the others.Aluminum is popular for cookware because it is inexpensive and lightweight.

Figure 9:Aluminum Utensils Used in Everyday Life

For years, some have alleged that aluminum cookware could be a cause of headaches, colitis and indigestion. Today we know these claims to be true, especially when acidic foods, such as tomatoes and okra, are cooked in aluminum cookware. Use of steel utensils on aluminum cookware can cause additional toxicity by scraping aluminum into food.

Examples of aluminum utensils for eating are the basics: cookware, cutlery, aluminum foil, aluminum mold, aluminum lunch box etc. Steak knives can also be made of aluminum. Aluminum plates and bowls also exist. However, these are less common and are less pleasing to the eye than the standard ceramic plates and bowls.

[43]http://www.rd.com/health/wellness/cooking-with-aluminum-foil/

Utensils used for stirring and cutting come in wide variety. Knives are an excellent example, and spatulas also can be made of aluminum. The same goes for graters, measuring spoons, measuring cups, bottle openers and can openers. The list goes on--essentially any stirring, opening or cutting implement can be made of aluminum.

Rounding out aluminum's uses, there is cooking itself. Nonstick pans can be made of aluminum, as can pots for boiling water or simmering stews. Aluminum lids also exist, as do aluminum baking trays.[44]

Aluminum Cans

Beer and soft drink cans are made exclusively from aluminum. Most metal beverage cans manufactured in the United States are made of aluminum, whereas in some parts of Europe and Asia approximately 55 percent are made of steel and 45 percent are aluminum alloy. Steel cans often have a top made of aluminum. The aluminum used in United States and Canada are alloys containing 92.5% to 97% aluminum, <5.5% magnesium, <1.6% manganese, <0.15% chromium and some trace amounts of iron, silicon and copper according to MSDS from aluminum producer Alcoa. Alloys used include 3004, 3105, or other 3xxx/5xxx series aluminum. Since these beverages are often highly acidic, even one beer or cola drink per day can lead to aluminum toxicity in susceptible individuals over a period of time. A more serious concern about aluminum cans is that many are lined with bisphenol A, or BPA. It's an additive that's designed to keep the aluminum from spreading to the food or drink stored in the cans. Unfortunately, it's also been linked to cancer, problems with brain development, disruption of the endocrine system, and reproductive disorders.[45]

To test the effects of drinking from cans, researchers in South Korea provided 60 adults over the age of 60 with soy milk either in a can or a glass bottle. Urine tests showed that those who drank from cans saw BPA levels up to 1,600% higher than those who drank from bottles, according to a post at Eureka Alert.[46]

[44]https://www.hunker.com/12362111/examples-of-aluminum-utensils
[45]https://www.isitbadforyou.com/questions/are-aluminum-cans-bad-for-you
[46]https://www.usatoday.com/story/news/nation/2014/12/14/bottle-chemical-bpa-health-newser/20397547/

Medicines

Aluminum compounds are commonly found in medicines, either as the active ingredient, or as additives used for various reasons. An example of aluminum-containing medicines is antacids which use aluminum hydroxide as the active ingredient. Most antacids contain significant amounts of aluminum hydroxide, including Maalox, Mylanta, Gaviscon, Riopan, Alka-Seltzer, Rolaids and many others. Buffered aspirin compounds, such as Ascriptin, also contain aluminum. Aluminum functions in these preparations as an anticholinesterase agent to counteract the laxative properties of the magnesium hydroxide which the antacids also contain. Antacids are available which do not contain aluminum, such as Tums and one type of Riopan. As much as 100 to 200 mg aluminum is found in some antacid tablets.[47]

Pharmaceutical blisters, one of the major components of medical plastic wastes, represent the largest segment of the market in terms of pharmaceutical packaging, and the recycling should be taken into consideration in order to improve hospital sustainability and reduce wastes. Pharmaceutical blisters consist chiefly of plastic films (80%–85%, mass fraction) and aluminum foils (15%–20%, mass fraction).[48]This aluminum content poses serious threat to our environment.

Anti-Perspirants

Aluminum chlorhydrate or other aluminum compounds are used in anti-perspirants to inhibit sweating. Deodorants, in contrast to anti-perspirants, simply emit a pleasant odor but don't inhibit sweating. Significant amounts of aluminum can be absorbed through the skin when anti-perspirants are used daily. Salts of aluminum such as aluminum chloride and aluminum-zirconium compounds are widely used in deodorants and antiperspirants. Research suggests that long-term use of such products can significantly increase the body burden of this toxic metal.[49]

Vaccines

Aluminum is used in vaccines as an adjuvant. An adjuvant is vaccine component that boosts the immune response to the vaccine. Adjuvants allow for lesser quantities of the vaccine and

[47]http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware/
[48]LEE B K, ELLENBECKER M J, MOURE E R. Analyses of the recycling potential of medical plastic wastes [J]. Waste Management, 2002, 22: 461-470.
[49]Guillard O Fauconneau B Olichon D Dedieu G Deloncle R (2004) Hyperaluminemia in a woman using an aluminum-containing antiperspirant for 4 years American Journal of Medicine 117(12):956-9

fewer doses. The adjuvant effects of aluminum were discovered in 1926. Aluminum adjuvants are used in vaccines such as hepatitis A, hepatitis B, diphtheria-tetanus-containing vaccines, Haemophilusinfluenzae type b, and pneumococcal vaccines, but they are not used in the live, viral vaccines, such as measles, mumps, rubella, varicella and rotavirus.[50]

Hemodialysis

"In a recent study we found that levels of bone aluminum were elevated in nearly all patients undergoing hemodialysis, especially those with osteomalacia." (Hodsman 1982).The kidneys appear to be the main excretory organs for aluminum and any impairment of renal function can result in aluminum retention. The degree of aluminum toxicity in renal failure depends upon the duration of aluminum exposure.

Drying Agents

Sodium silico-aluminate is a fine powder that is used to keep cocoa, salt and other products, dry. Baking powders also frequently contain aluminum. Table salt (not sea salt) may contain aluminum acetate that is used as a drying agent to prevent caking.

Water

According to the world health organization (WHO) aluminum constitutes about 8% of the Earth's crust, making it the most abundant metal on the planet. salts of aluminum are widely used in water treatment plants to reduce organic matter, turbidity and microorganism levels - "Such use may lead to increased concentrations of aluminum in finished water (i.e. municipal water supply)." Most municipal water supplies add aluminum to the drinking water as a flocculating agent (removes dirt). In addition, some water supplies may contain high amounts of naturally occurring aluminum compounds.

Most meats, fish, fruits, and vegetables naturally contain traces of aluminum. Cooking foods in aluminum pots and pans or in aluminum foil can increase their aluminum content. Aluminum containingantacids, food additives, and antiperspirants are additional sources of exposure. Drinking water is not usually a significant source of aluminum exposure. However, high levels of aluminum have recently been found in groundwater in northwestern and central Wisconsin.

Other

[50] http://www.chop.edu/centers-programs/vaccine-education-center/vaccine-ingredients/aluminum

Sodium aluminum phosphate is used as an emulsifier in processed cheese and potassium alum is used to bleach flour.[51]

Aluminum Recycling

Compared to producing virgin aluminum from raw bauxite, recycling old aluminum consumes just 5% of the energy and releases a mere 5% of the greenhouse gases**.** Infinitely recyclable, aluminum loses none of its integrity even when it is melted down repeatedly, plus, the whole recycling process can be achieved in less than 60 days flat. Recycling just four cases of beer containing a total of 96 cans saves enough energy to keep a laptop computer running for well over a month. Aluminum is economical to recycle and yields consistent income for municipalities (despite fluctuations in scrap prices) as well as charities and community causes. Landfills across the globe continue to be the final resting place for infinite numbers of aluminum beverage cans, which, when incinerated, contaminate air with toxic compounds and take up to 500 years to fully decompose. By recycling already-manufactured aluminum materials, precious space can be conserved in landfills and no new waste materials are produced.[52]

Precautions

Aluminum is relatively soft and will be dinged up and scratched before you know it, by the burner grates or metal utensils. Even anodized aluminum will chip/flake off if you strike it against other hard surfaces enough times. Thin aluminum will warp over time, which can be a problem if you have a flat cooktop. To avoid this, try to buy relatively thick (3mm+) aluminum with either anodization or a stainless steel disc on the bottom or both. Also avoid large temperature shocks like pouring cold water over a hot aluminum pan, as that is a great way to wrap your pan.

Aluminum is not compatible with the vast majority of induction cook tops. There are a few expensive, exotic induction cook tops that will (inefficiently) work with aluminum and copper. It is not necessary to season bare aluminum or anodized aluminum. Try to avoid using putting your aluminum cookware through dishwashers with harsh detergent. Even anodized aluminum may have a few small spots of weakness where the anodized layer chipped off, and harsh detergents may eat away at the exposed aluminum. This is particularly a problem for cladded designs where the aluminum layer is between two thin (~0.5 mm thick)

[51] http://www.arltma.com/Articles/AlumToxDoc.htm
[52]https://recyclenation.com/2010/11/aluminum-extraction-recycling-environment/

stainless steel layers. If the aluminum gets eaten away, you are left with two very thin, stainless steel edges that can cut fingers and sponges. If you absolutely must wash aluminum with a dishwasher, try using detergents that explicitly state that they are safe for use with aluminum.[53]

Alternative to Aluminum Cookware[54]

1. Ceramic Cookware and Bake ware
2. Cast Iron Cookware
3. Le Creuset Enameled Cast Iron and Stoneware
4. Regular Stoneware
5. Glass and Corning ware
6. Stainless Steel

[53]https://www.centurylife.org/aluminum-aluminium/
[54]wellnessmama.com/5148/safest-cookware-options/

r

Design of the Study

The study was conducted in two ways,

1) Laboratory study and

2) Survey study

1) **Laboratory study**

Four samples of Aluminum cookware were collected from local markets of Bangladesh and send to San Francisco for laboratory analyses. The test included X-ray fluorescence (XRF) analysis and leaching tests.

XRF screening of cookware samples was conducted using a NitonXL3t GOLDD XRF spectrometer (Thermo Fisher Scientific, Billerica,MA). Prior to analysis, an internal system calibration was performed.Samples were analyzed for metals in "general metals" mode using analuminum alloy (grade 6061) reference material.

There is no standardizedmethod to replicate normal cooking for themeasurement of metals leaching from aluminum cookware. Here, weused a 2 h boiling extraction with dilute acetic acid (4% vol/vol), an extractionwhich simulates cooking with weakly acidic foods such as tomato sauce.[i]Volumetric flasks and all other glassware used in these experimentswere rigorously acid-washedwith concentrated nitric acid prior to analysis.All cookware was washed with soap and water prior to undertakingthese experiments.Samples were leached with 4% acetic acid (vol/vol) for 2 h in boilingsolutions. Cookwarewas filled towithin 1 cm of the rim, and brought toa gentle boil on a hotplate. Pots that had curved rather than flat

bottomswere heated over natural gas burners. For pots which did not have lids, glass plates were placed on top of the pots to retard evaporation. Thesamples were then boiled for 2 h, during which time 4% acetic acidwas added as needed tomaintain solution volumes. After cooling, solutionswere transferred directly to 50 mL polyethylene test tubes andstored under refrigeration until analysis.

2) **Survey study**

ESDO has taken the initiatives to conduct a survey to determine the percentage of use, level of awareness and production ratio as well as to promote regulations.

Both market survey and questionnaire survey was conducted to assess the rate of production and import, the level of awareness among people about the issue and the percentage of usage of aluminum cookware.

For the field survey Dhaka metropolitan area and adjoining Munshiganj, Manikganj, Savar, Gazipur and Tongi area was selected as sampling area. The survey was done on 1800 respondents of which 800 were from Dhaka Metropolitan Area and 1000(200 per district) respondents were from Munshiganj, Manikganj, Savar, Gazipur and Tongi.

Results and Discussion

1) **Laboratory study**

Leaching of aluminum, arsenic, cadmium and lead from cookware

Aluminum, arsenic, cadmium and lead exposure from the cookware was recorded. Estimated exposures for all metals were based on the 250 ml typical serving size, which has been used in other dietary studies in developing countries[55]. The results are discussed below:

Aluminum

The estimated mean exposure from the cookware (averaged for all items and extractions) is 125 mg per serving, more than six times greater than the World Health Organization (WHO) PTWI of20 mg day−1 for a 70 kg adult (WHO, 2011b).

[55]Coulibaly, A., O'Brien, H., Galibois, I., 2009. Development of a Malian food exchange system based on local foods and dishes for the assessment of nutrient and food intake in type 2 diabetic subjects. S. Afr. J. Clin. Nutr. 22, 31–35.

Arsenic

All four cookware items from Bangladesh, (a country with serious arsenic poisoning issues due to contaminated groundwater)were found to release arsenic up to a maximum of 6 µg per serving.

Cadmium

The maximum exposure of 7.5 µg perserving was found from a pot from Bangladesh. All the four items were found to release around this amount.

Lead

From four cookware samples an average of 2 µg/serving lead was found after 1rst boiling. So it was obvious that though lead are not much used during making aluminum alloys, cookware exposes lead. this is only due to the scrap metal used for making the cookware, particularly low grade cookware metals.

Table 3: The exposure of Al, As, Cd and Pb fromCookware after first boil.

Item	**Boil**	**mg/serving Al**	**µg/serving As**	**µg/serving Cd**	**µg/serving Pb**
A	1	9	6	Nd	2
B	1	219	5	7.5	1.9
C	1	218	5	6.7	2.1
D	1	154	3	7.1	2

Aluminum, arsenic, cadmiumand lead leached per 250ml serving based on a 2 h simulated cooking extraction with 4% acetic acid.

2) **Survey study**

Percentage of Usage

From the survey conducted it was found that 97.56% of the people (both urban and rural) use aluminum utensils (Cookware, bake ware, cutlery etc.). In Dhaka city, among 800 households, 783 said that they use aluminum cook wares. Among 200 people in each city, 190 (95%), 194 (97%), 195 (97.5%), 200 (100%) and 196 (98%) people assured the uses of aluminum cookware in Dhaka, Munshiganj, Manikganj, Savar, Gazipur and Tongi respectively.

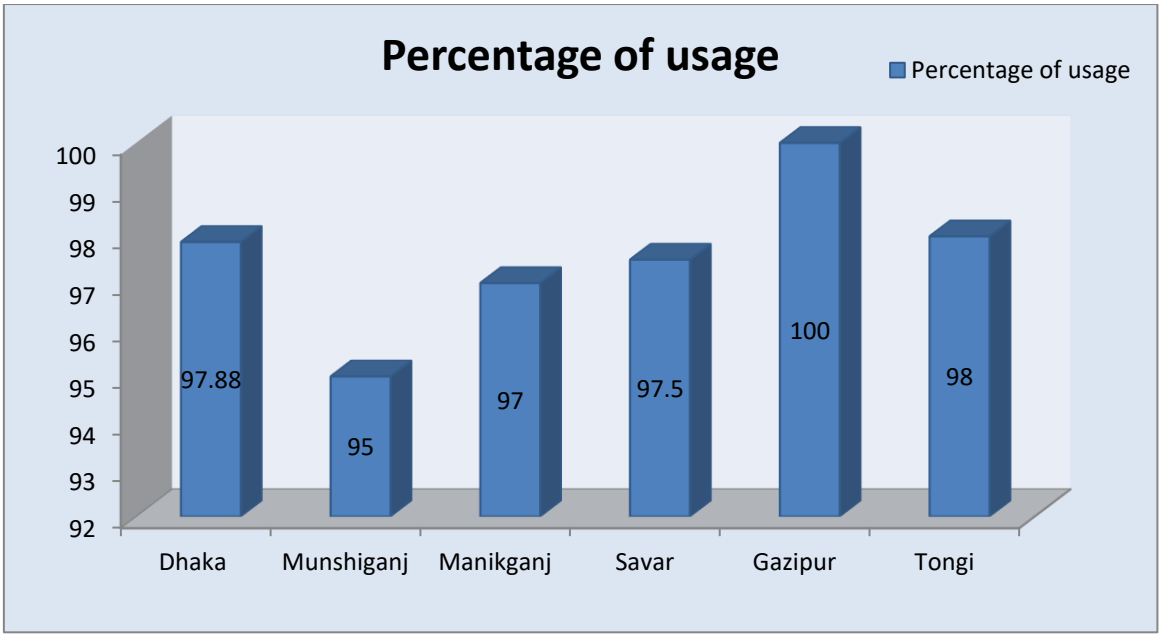

Figure 10: Percentage of usage of Aluminum cookware in the city of Dhaka, Munshiganj, Manikganj, Savar, Gazipur and Tongi respectively

Level of Awareness

It was very unfortunate that most of the people surveyed were found to be unaware of the fact. The level of awareness was found very low, about 4.94% in survey locations. It was observed that only 89 people were aware of the fact that aluminum cook wares poses risks.

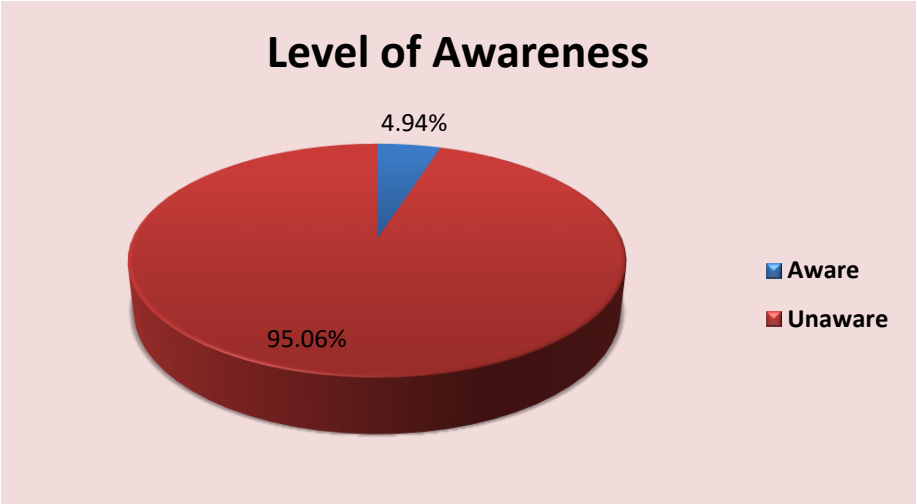

Figure 11: The level of awareness among people in the city of Dhaka, Munshiganj, Manikganj, Savar, Gazipur and Tongi respectively.

Production

Most of the aluminum cookware products in Bangladesh are manufactured locally. There are several Aluminum industries in Bangladesh who produces aluminum utensils. It was found that the ratio of local products to imported products is 80:20. Among imported products most are from India, Thailand and Pakistan.

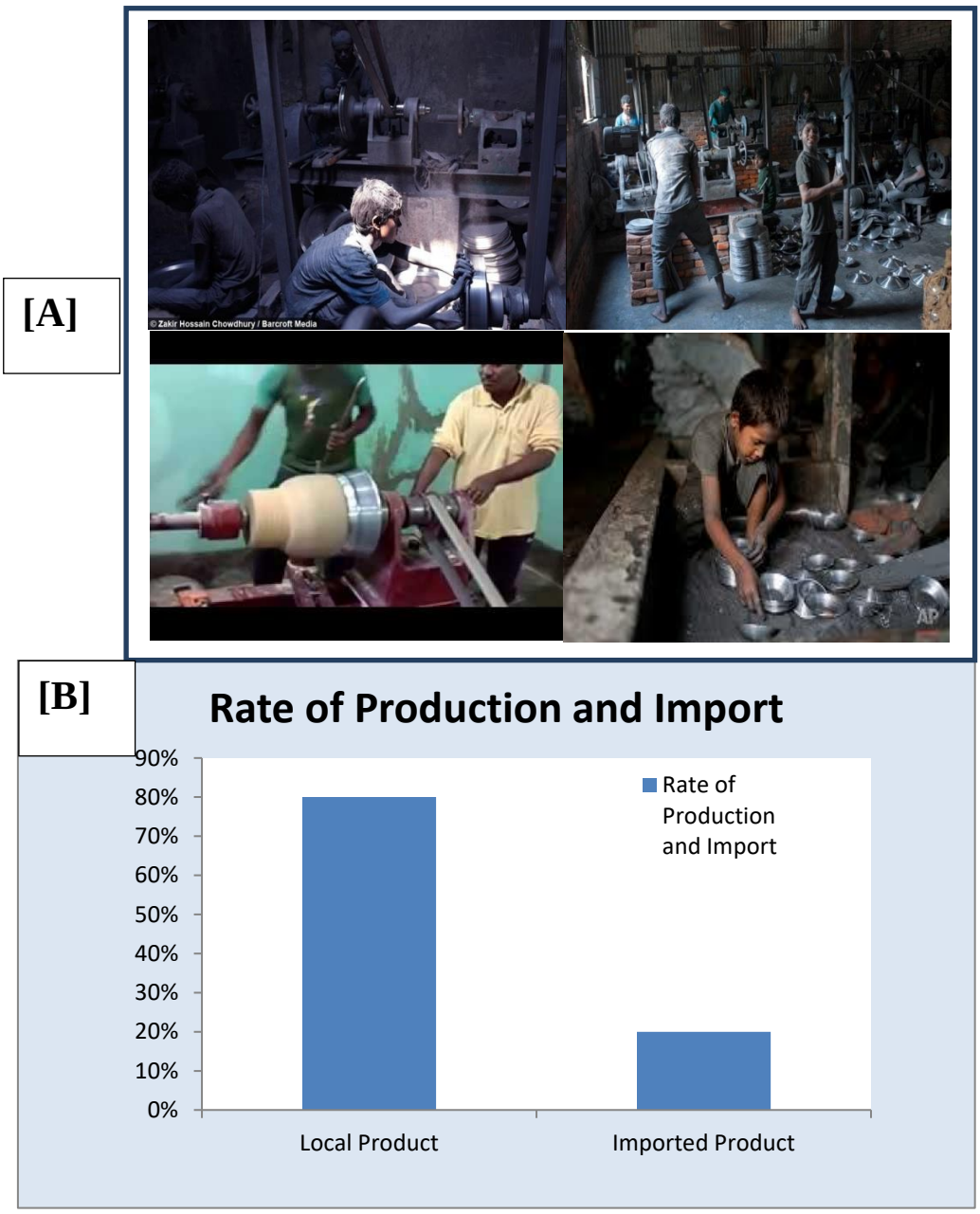

Figure 11: Scenario of Aluminum cookware production industries in Bangladesh [A] and rate of production and Import % of Aluminum cookwarein Bangladesh [B]

Summary and Conclusion

If there's ever been any dangerous cookware you've heard about before, it's likely aluminum. Warnings have abounded for years about aluminum toxicity and the link between excess aluminum and Alzheimer's disease. The concern about aluminum cookware comes from the observation that Alzheimer's patients have more aluminum in their brains than people who do not suffer from Alzheimer's disease. However, it is likely that aluminum does not cause Alzheimer's. Instead, the disease processes of Alzheimer's may allow for more aluminum to be deposited in a patient's brain. With this understanding, let's consider aluminum cookware.

It is unlikely that significant amounts of aluminum are released from aluminum cookware. The amount of aluminum found in foods cooked in aluminum pots is much lower than the amount usually found in foods, medicines and antiperspirant. It is important, however, to make sure the surface of the cookware is undamaged.

More than half of the cookware on the market today is made from aluminum. This is because aluminum is a good conductor of heat and is used frequently with non-stick pots and pans. The makers of aluminum cookware warn against storing highly acidic or salty foods in aluminum cookware. But its dangerous in various ways. Aluminum, copper, iron, and steel (not 'stainless') are all reactive. They conduct heat very efficiently, and therefore, do a great job of cooking our food evenly. However, these metals are reactive with acidic and alkaline foods. And ultimately people ingest these metals at a toxic concentration. Immediate steps should be taken to address the problem.

Current Policy Situation

There are no regulations regarding the production, import, use and disposal of aluminum utensils in Bangladesh. ESDO has done this study with a view to raise awareness among local people as well as policy makers to achieve a regulation regarding aluminum production and use.

Recommendation

Regulations and recommendations can be expressed as "not-to-exceed" levels, that is, levels of a toxic substance in air, water, soil, or food that do not exceed a critical value that is usually based on levels that affect animals; they are then adjusted to levels that will help protect humans. An immediate regulation on the import, sell and use of aluminum cook ware is highly recommended. More and more awareness initiatives from government and non-government sectors will play a vital role in addressing the problem.

Some regulations and recommendations for aluminum include the following[56]:

Drinking water	The EPA has recommended a Secondary Maximum Contaminant Level (SMCL) of 0.05–0.2 mg/L for aluminum in drinking water. The SMCL is not based on levels that will affect humans or animals. It is based on taste, smell, or color.
Consumer products	The FDA has determined that aluminum used as food additives and medicinals such as antacids are generally safe. FDA set a limit for bottled water of 0.2 mg/L.
Workplace air	OSHA set a legal limit of 15 mg/m^3 (total dust) and 5 mg/m^3 (respirable fraction) aluminum in dusts averaged over an 8 hour work day.

[56]Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Toxicological profile for Aluminum. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

References

Semwal, A. D., A. Padmashree, M. A. Khan, G. K. Sharma, and A. S. Bawa. 2006. Leaching of aluminum from utensils during cooking of food. Journal of the Science of Food and Agriculture 86: 2425-2430.

[2]https://embracingimperfect.com/nontoxic/nontoxic-cookware

[3]http://news.ashland.edu/article/study-conducted-au-warns-lead-and-other-toxic-metals-cookware-made-scrap-metal-contaminates

[4]http://www.ei-resource.org/illness-information/related-conditions/heavy-metal-toxicity/

[5]https://www.researchgate.net/publication/233540637_Leaching_of_aluminium_from_cooking_pans_and_food_containers

[6]https://www.sciencedaily.com/terms/heavy_metals.htm

[7]https://en.wikipedia.org/wiki/Metal_toxicity

[8]http://familywellnesshq.com/heavy-metals-sources-toxicity

[9]http://www.encyclopedia.com/science-and-technology/chemistry/compounds-and-elements/aluminum-alloys

[10]http://www.arltma.com/Articles/AlumToxDoc.htm

[11]http://www.encyclopedia.com/science-and-technology/chemistry/compounds-and-elements/aluminum-alloys

[12]Marks' Standard Handbook for Mechanical Engineers, 8th Ed., McGraw Hill, pp. 6-50 to 6-57

[13]http://www.makeitfrom.com/material-properties/3003-AlMn1Cu-3.0517-A93003-Aluminum

[14]https://www.centurylife.org/aluminum-aluminium/

[15]https://www.americanelements.com/meltingpoint.html

[16]http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware/

[17] Anderson, R. A. 1995. Dietary and metabolic effect in trivalent chromium retention and distribution in rats. Biol. Trace Elem Res. 50:97-108.

[18]Cabrera, C., Lloris, F., Gimenze, R., Olalla, M., Lopez, C., (2003). Mineral content in legumes and nuts: Contribution to the Spanish dietary intake. Sci. Total Environ. 308:1-14.

[19]http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware/

[20]https://www.sciencedaily.com/releases/2017/01/170123110345.htm

[21]http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware

[22]Dan E. U. and Ebong G. A., 2013, IMPACT OF COOKING UTENSILS ON TRACE METAL LEVELS OF PROCESSED FOOD ITEMS; Annals. Food Science and Technology.P-350.

[23] Jeffrey D. Weidenhamer, Peter A. Kobunski, Gilbert Kuepouo, Rebecca W. Corbin, and Perry Gottesfeld (2014), Lead exposure from aluminum cookware in Cameroon.J. Science of the Total Environment.p-339-347.

[24]Lanphear BP, Hornung R, Khoury J, Yolton K, Baghurstl P, Bellinger DC, et al. Low-level environmental
lead exposure and children's intellectual function: an international pooled analysis. Environ Health Perspect 2005;113:894–9.

[25]XieXH, Tan ZW, JiaN, Fan ZY, Zhang SM, Lu YY, et al. Blood lead levels among children aged 0 to 6 years in 16 cities of China, 2004–2008. Chinese Med J Peking 2013;126:2291–5.
[26]Al Juhaiman, L.A., 2012. Estimating aluminum leaching from aluminum cookware in different vegetable extracts. Int. J. Electrochem. Sci. 7, 7283–7294.

[27]Mohammad, F., Al Zubaidy, E., Bassioni, G., 2011. Effect of aluminum leaching process of cooking wares on food. Int. J. Electrochem. Sci. 6, 222–230.

[28]https://www.thermofisher.com/blog/metals/lead-found-in-pots-made-from-recycled-scrap-metal

[29]Mailloux RJ Hamel R and Appanna VD (2006) Aluminum toxicity elicits a dysfunctional TCA cycle and succinate accumulation in hepatocytes Journal of Biochemical and Molecular Toxicology 20(4):198-208

[30]http://www.drpepi.com/aluminum-poisoning.php

[31]***https://media.licdn.com/mpr/mpr/shrinknp_800_800/p/6/005/0a4/21d/2b3a1b6.jpg***

[32]ttps://classconnection.s3.amazonaws.com/403/flashcards/3629403/png/atrophy-14249AC1AD912A56462.png

[33]https://image.slidesharecdn.com/physiologyofbone2-140920220444-phpapp02/95/physiology-of-bone-2-31-638.jpg?cb=1411250709

[34]https://www.dhs.wisconsin.gov/publications/p0/p00261.pdf

[35]http://greengroundswell.com/aluminum-beverage-cans-environmental-impact/2014/07/17/

[36]Petrela J Câmara VM Kennedy G Bouyahi B Zayed J (2001) Health effects of residential exposure to aluminum plant air pollution Archives of Environmental Health 56(5):456-60

[37]Saiyed SM and Yokel RA (2005).Aluminium content of some foods and food products in the USA, with aluminium food additives Food Additives & Contaminants 22(3):234-44

[38]https://answers.yahoo.com/question/index?qid=20110216094851AA17Q1r

[39]Saiyed SM and Yokel RA (2005).Aluminium content of some foods and food products in the USA, with aluminium food additives Food Additives & Contaminants 22(3):234-44

[40]https://answers.yahoo.com/question/index?qid=20110216094851AA17Q1r

[41]Saiyed SM and Yokel RA (2005).Aluminium content of some foods and food products in the USA, with aluminium food additives Food Additives & Contaminants 22(3):234-44

[42]https://answers.yahoo.com/question/index?qid=20110216094851AA17Q1r

[43]http://www.rd.com/health/wellness/cooking-with-aluminum-foil/

[44]https://www.hunker.com/12362111/examples-of-aluminum-utensils

[45]https://www.isitbadforyou.com/questions/are-aluminum-cans-bad-for-you

[46]https://www.usatoday.com/story/news/nation/2014/12/14/bottle-chemical-bpa-health-newser/20397547/
[47]http://www.livestrong.com/article/143570-poisons-from-aluminum-cookware/

[48]LEE B K, ELLENBECKER M J, MOURE E R. Analyses of the recycling potential of medical plastic wastes [J]. Waste Management, 2002, 22: 461-470.

[49]Guillard O Fauconneau B Olichon D Dedieu G Deloncle R (2004) Hyperaluminemia in a woman using an aluminum-containing antiperspirant for 4 years American Journal of Medicine 117(12):956-9

[50]http://www.chop.edu/centers-programs/vaccine-education-center/vaccine-ingredients/aluminum

[51]***http://www.arltma.com/Articles/AlumToxDoc.htm***

[52]https://recyclenation.com/2010/11/aluminum-extraction-recycling-environment/

[53]https://www.centurylife.org/aluminum-aluminium/

[54]wellnessmama.com/5148/safest-cookware-options/

[55]Coulibaly, A., O'Brien, H., Galibois, I., 2009. Development of a Malian food exchange system based on local foods and dishes for the assessment of nutrient and food intake in type 2 diabetic subjects. S. Afr. J. Clin. Nutr. 22, 31–35.

[56]Agency for Toxic Substances and Disease Registry (ATSDR). 2008. Toxicological profile for Aluminum. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.