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Heavy metal in drinking water its effect on human health and its treatment techniques - a review

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Abstract

In human life, the dispute related to drinking water pollution is increasing day by day. In this article we discussed the contamination of drinking water with heavy metals. Heavy metals are a metallic element that has a relatively high density, specific gravity, or atomic weight and has toxic effects. Generally, humans are more likely to be exposed to heavy metals through water consumption and thus bioaccumulation of toxic metals takes place in the human body. Which causes serious human health hazards and may induce cancer and other risks. The main sources for drinking water pollution are improper dumping of domestic and industrial wastes. The writing purpose of this review article is to increase the awareness about heavy metal and its high concentration effect on living things. Point out many diseases that causes, due to the high concentration of heavy metal in drinking water, also point out the reason of why heavy metal concentration increasing in water. Many water treatment technique has also been discussed in this paper, all these treatments that helps to remove excess amount of heavy metal in drinking water. The data presented in this review have been taken out from different published studies. Water is the basic need of life. In short "healthy water gives the healthy life".

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Introduction

In this article use the word heavy metal to the identification of toxic metal. Healthy drinking water is the basic need of the human health. Contaminated drinking water is a significant risk to human health (WHO, 2011). Total Water on earth contains 3 % fresh water. Only a little portion (0.01%) of this fresh water is available for human utilization (Hinrichsen and Tacio, 2002). Even this little portion of fresh water is under huge pressure due to rapid rise of population, urbanization, climatic change, utilization of natural resources and food requirement. The demand of fresh water for agricultural and industrial purposes is also increasing with modernization, due to these a severe water shortage can result in next decades. Only a few heavy metals (e.g. copper, selenium, zinc) with low concentration are necessary to maintain the metabolism of the human body. When these elements cross their limits those creates the negative impact on human health (USEPA, 2015).The high concentration of heavy metal intensively effects on health, no. of disease increases day by day like cancer that are associated with heavy metal (Volety, 2008; Karavoltsos *et al.*, 2008; Delpla *et al.*, 2009; Liu *et al.*,2009, 2011; Montuori *et al.*, 2013; Mandour and Azab, 2011;Shanbehzadeh *et al.*, 2014,USEPA, 2014, 2015). The heavy metalscan enter into the environment through anthropogenic activates and natural process. An industrial process like electroplating, metal smelting and industrial waste are also the sources of heavy metal (He *et al.*, 2008). Most of the countries do not properly recycle agriculture waste, industrial wastewater and Industrial waste, so it is also a source of excess heavy metal. (Gupta, 2008). Liu *et al.* (2011, 2012). In China Hong Feng Lake, the main source of heavy metal identified industrial effluents and bio-geo process. (Szefer *et al.*, 1999).If we talk about the concentration of arsenic in Bangladesh. There is fifty district where the concentration of arsenic is greater than 50 µg/L (Uddin and Huda, 2011; Jiang *et al.*, 2013). Heavy metal like arsenic causes a source of contamination in a floodplain and in a deltaic region (Chakraborti *et al.* 2010). Sediments that are below in the water adsorb metal and provide a continuous source of toxic water (Chowdhury *et al.*, 2004; Wu *et al.*, 2014; Wang *et al.*, 2015). The industrial process, waste and traffic pollution are the essential source to introduce toxic metals (lead and mercury) in the atmosphere, these metal accumulate in soil and then enter to water gradually by surface runoff due to acid rain (Wang *et al.*, 2015). The sub-chronic and chronic effect also due to heavy metal. Forty million people of Bangladesh affected health issue due to drinking unhealthy water (Karim,2000; Chakraborti *et al.*, 2010; Uddin and Huda, 2011) Japan also have issue of contaminated water. In the Jinzu River have a greater concentration of cadmium due to Kamioka Zinc Mine in Japan that is highly affected by health (Yoshida *et al.*, 1999).

In 2011, 2015 WHO and USEPA point out an allowed limit of the toxic metal in drinking water. Many reports have published that focus on water quality and intensively point out effect, due to a high concentration of heavy metal in water, also point out the source of contamination, a risk that creates on health and gives the solution to control(World Bank, 2016), (WHO, 2011).

Heavy Metal and its Effect On Health

Heavy metals introduce in groundwater and surface water by human activities (unstandardized Industrial process, municipal waste, excess and sometime unrequired chemicals are used in agriculture process) (Midrar-Ul-Haq *et al.*, 2005). In most areas of Pakistan, the concentration of heavy metals ishigher than the permissible limit of WHO, (Table 3) show summarized the result of many reports. Some heavy metals are essential for health but in limited concentration, high concentration creates harmful effect on health. Zinc (Zn) and Copper (Cu) are important for health but in limited concentration (Solomons and Ruz, 1998), (Fosmire, 1990; Singh *et al.*, 2006). The WHO permissible limit of drinking water for Cu 2 mg/l.

Zinc (Zn)

Zinc is an essential trace element, which is required in small quantity to maintain human health. Zinc helps in production of hormones, growths, improvement of immune and digestive system. Having drinking water contain higher or lower concentration of zinc than the required amountinduces undesirable health effects. Increased Zinc can result distinguished health problems such as stomach cramps, skin inflammation, vomiting, nausea, anemia, root trouble in pancreas, protein metabolism and further it can generate arteriosclerosis. Zinc deficiency can lead to fertility issue and also increase the risk of diabetes.

The WHO permissible limit of drinking water for Zn is 3mg/l.Since a protective coating is easily constructed on the surface of zinc metal, which avoids atmospheric corrosion. Zinc is widely used in galvanization industry such as steel processing, shipbuilding, automobiles and construction. Zinc oxide is also used in the pharmaceutical, paint, rubber, cosmetics, plastics, inks, soaps, batteries and textiles industries. These industries are responsible for the high zinc metal concentration if they don't apply an effective treatment for the removal of zinc form industrial waste.

Manganese (Mn)

Manganese is an important trace mineral that is needed by our body in little amounts for the production of digestive enzymes, absorption of nutrients, wound healing, bone development and immune-system defenses. Negative health effects can be caused by insufficient or excessive intake of manganese. Although manganese deficiency in humans is comparatively rare because manganese is present in many common foods. A deficiency can cause serious health problems including weak bones (osteoporosis), muscle and joint pain, and sexual dysfunction. Human exposure to higher amount of manganese can result severe disorders in nervous system, and long term exposure in its worst condition can cause permanent neurological effects with symptoms characterized by "Parkinson's disease," Symptoms of Parkinson's disease includes weakness, shaking, slowness, anxiety, quieter speech, depression, memory loss and frequent urination. Manganese is a mineral that naturally occurs in rocks and soil, but human activities are much responsible for underground water pollution by this element (USEPA, 2004).There are some places in Pakistan where the concentration of Manganese found higherthan the WHO allowed limit (0.5mg/L).

The concentration of Manganese found (2.56mg/L), five times greater than WHO permissible limit in groundwater from Khyber Pakhtoonkhwa (Midrar-Ul-Haq *et al.*, 2005), whereas in water sample from Faisalabad city it is reported (1.06mg/l), approximately double the WHO standard limit (Mahmood and Maqbool, 2006).However, other studies show the Mn concentration in most areas of Pakistan found within safe limit.

Iron (Fe)

Iron (Fe) is an essential element for human health that performs various function in our body, the most well-known of them is production of protein hemoglobin, which carry oxygen from our lungs to transfer it throughout the body. Insufficient or excess levels of iron can have negative effect on body functions (Anonymous, 2008). An iron deficient person may have symptoms like weakness, Dizziness, headaches, Shortness of breath, Pale skin, Chest pain. Whereas an excess iron in vital organs, increases the risk for liver disease (cirrhosis, cancer), heart failure, diabetes mellitus, depression, osteoarthritis, osteoporosis, infertility, hypothyroidism, abdominal pain, hypogonadism, numerous symptoms and in some cases it becomes cause of premature death.(Beckman *et al.*, 1999; Parkkila *et al.*, 2001), (Ellervik *et al.*,2001; Parkkila *et al.*, 2001; Perez de Nanclares *et al.*, 2000), (Berg *et al.*, 2001; Sayre *et al.*, 2000). In drinking water WHO recommended value for iron is 0.3mg/l.It is sad to say that the concentration of iron is high in Pakistan water. According to PCRWR report, surface water and groundwater contain 40% iron and 28% iron respectively that is very high. (PCRWR, 2005).

In different areas of Pakistan, the concentration of iron in groundwater ranging from 0 to 3.7mg/L and 0.01 to 9 mg/L in surface water (Table 1).

Table 1. Heavy/toxic metals concentrations (mg/L) in ground and surface water samples of Pakistan. Data are extracted from various individual studies and arranged chronologically based on year of publication of the reviewed articles. Values given represents the mean values or the range from minimum to maximum and where both range and mean are given, the value in parenthesis () is the mean value.

S. no.	Sampling location Zn Cu Fe Mn CdCr NiPb HgAs(μg/L) Reference A Groundwater
1.	Various spots in 4.02 0.09 – – 0.04 0.34 0.50 2.0 0.01 80 Rahman *et al.* (1997) Karachi
2.	Tube Well water 0.009 0.02 0.07 0.02 0.001 0.04 0.03 0.03 – – Lone *et al.* (2003) Hasan abdal
3.	Shallow wells in 0.047–0.340.26–0.34 0.0–0.30 0.071–0.21 0.0–0.04 –0.0–0.68 0.27–0.38 – –Ilyas and Sarwar (2003)the vicinity of Palosidrain Peshawar (n=13)
4.	Deep Wells in the 0.0–0.0820.558–0.598 0.46–0.99 0.0–0.306 0.0–0.056 – 0.0–0.52 0.0–0.49 – –Ilyas and Sarwar (2003) vicinity of Palosidrain Peshawar(n=3)
5.	Well water District– – 0.07–2.7 0.06–1.0 – – – – – 60–1000[a] Nickson *et al.* (2005)Multan (n=3)
6.	Well water District– – 0.0–1.65 0.0–0.69 – – – – – 0.0–400[a]Nickson *et al.* (2005) Muzaffargarh (n=46)
7.	Tube well water0.048 0.032 2.39 0.124 0.041 0.03 0.656 0.24 – –Saif *et al.* (2005) Korangi, Karachi (n=4)
8.	Well water from 0.002–0.27 0.004–0.67 0.01–0.43 0.08–2.56 0.01–0.07 0.01–0.30 0.002–3.66 0.02–0.73 – –Midrar-Ul-Haq *et al.* (2005) Charsadda and (0.13) (0.21) (0.16) (1.22) (0.04) (0.14) (0.96) (0.33) Risalpur NWFP(n=8)
9.	Well water from 0.04–0.520.01–0.210.51–2.390.07–0.120.02–0.040.003–0.070.01–2.190.10–0.24––Midrar-Ul-Haq *et al.* (2005) Korangi Karachi (n=4) (0.26)(0.10)(1.22)(0.10)(0.03)(0.03)(1.20)(0.15)
10.	Groundwater1.84 1.30 3.70 1.06 – 0.01 0.13 0.12 – –Mahmood & Maqbool (2006) Chakera, Faisalabad
11.	Tube wells in0.007–0.0660.87–0.893 0.004–0.037 0.059–0.1640.007–0.0250.017–0.1110.03–0.066 0.21–1.20 – – Nasrullah *et al.* (2006)Gadoon, NWFP
S. no.	Sampling location Zn Cu Fe Mn CdCr NiPb HgAs(μg/L) Reference
12.	Tap water industrial0.050 0.030 0.50 0.15 – – 0.00 0.001 – – Sial *et al.* (2006) estate, Hattar, NWFP
13.	Tube and dug wells0.01–0.23 0.25–0.450.01–0.200.06–0.22 0.01–0.060.03–0.160.38–1.750.20–0.97 – – Tariq *et al.* (2006) Hayatabad, Peshawar (n=4)(0.10)(0.36)(0.08)(0.12)(0.03)(0.09)(0.88)(0.66)
14.	Kalalanwala, Punjab – – – – –– –– – – 32–1900Farooqi *et al.* (2007a)(n=24)
15.	Well water from 0.01–1.08–0.02–11.80.01–0.170.001–0.0270.05–9.800.001–0.24 0.003–0.26 –– Tariq *et al.* (2008)residential area(0.14)(2.57)(0.04)(0.007)(2.12)(0.08)(0.11) Kasur city (n=68)
16.	Groundwater from0.0–0.810.01–0.17 0.0–0.83 0.0–0.09 –0.0–0.300.01–0.22 0.11–0.81 – – Ullah *et al.* (2009) different spots in(0.16)(0.06)(0.30)(0.03)(0.03)(0.10)(0.49)Sialkot city (n=25)
17.	Hand pumps water– –– – – – – – – – 23.3–96.3 Arain *et al.* (2009) in the vicinity of(60.2) Manchar Lake, Sindh (n=1944)
1.	Tarbela Reservoir 0.028 0.04 0.012 0.018 0.004 0.003 0.061 0.107 0.014 620Ashraf *et al.* (1991)
2.	Chashma Reservoir 0.029 0.004 0.004 0.004 0.003 0.071 0.065 0.058 0.017 750Ashraf *et al.* (1991)
3.	Lloyd Reservoir 0.028 0.0040.012 0.0180.002 0.002 0.061 0.107 0.14 620Ashraf *et al.* (1991)
4.	River Ravi different 0.01–0.03 0.001–0.006 0.042–0.127 0.0013– 0.0002–0.0003–0.0012–0.0004–0.0003– 0.32–1.8 Tariq *et al.* (1994)sites (n=5)0.0097 0.00140.00140.00130.00170.0009
5	Palosi drain,0.0–0.239 0.0 0.37–0.75 0.017–0.242 0.0–0.004 – 0.0–0.18 0.0–0.34 – –Ilyas and Sarwar ((2003) Peshawar (n=4)
6	Surface water from0.003–0.080.01–0.770.01–1.290.01–1.11 0.002–0.090.01–0.12 0.01–1.52 0.02–0.38 – – Midrar-Ul-Haq *et al.*(2005) different spots(0.04)(0.20) (0.19) (0.22) (0.02)(0.04)(0.21)(0.16) in NWFP (n=16)
S. no.	Sampling location Zn Cu Fe Mn CdCr NiPb HgAs(μg/L) Reference
7.	Malir River in0.06–0.290.01–0.840.13–2.91 0.05–0.570.002–0.070.03–0.29 0.02–1.060.09–0.32 – –

	Midrar-Ul-Haq *et al* (2005) Karachi (n=8)(0.16)(0.31)(0.78)(0.33)(0.04)(0.10)(0.59)(0.19)
8.	River Chenab – – 0.18 0.28 – – – – – 7Nickson *et al.* (2005) (n=1)
9.	Canal water, 0.04–0.05 0.59–0.73 0.90–1.02 0.61–0.71 0.09–0.14 0.13–0.17 0.33–0.39 0.34–0.43 – –Nazif *et al.* (2006)
	Akbarpura area, Nowshera, NWFP(n=9)
10.	Bara River,0.02–0.06 0.90–1.20 1.29–1.75 0.77–0.85 0.15–0.20 0.16–0.29 0.53–0.72 0.43–0.62 – –Nazif *et al.* (2006Akbarpura area, Nowshera, NWFP (n=9)
11.	Kalar Kahar Lake,0.44–2.82 0.01–1.20 0.20–5.46 – 0.01–0.05 – 0.04–0.25 0.01–0.30 – –Raza *et al.* (2007) Chakwal, Punjab
12.	MNVD, Sehwan, 0.0041–0.0072 0.003–0.0116–– 0.0001–– 0.0002– 0.004–– –Mastoi *et al.* (2008) Jamshoro, Sindh (n=3) 0.00840.01850.0180.0052 0.0096
13.	Manchar Lake0.0046–0.0006–0.0073–– 0.0001–– 0.0004–0.0057–– – Mastoi *et al.* (2008) Jamshoro, Sindh (n=9) 0.03480.01960.01780.002 0.00960.014
14.	Hudaira drain,1.7 0.45 7–9 0.85 0.18 0.07 0.93 0.03 – – Kashif *et al.* (2009) Lahore
15.	Manchar Lake –– – – – – – – – 35–157 Arain *et al* (2009.) Jamshoro, Sindh (n=540) (97.5) WHO Standard 3.00 2.00 0.30[c] 0.5 0.003 0.05 0.02 0.01 0.001 0.01

a. Arsenic was determined in the field.

b. Study was conducted on a monthly basis for one year. The values given shows the range throughout the year.

c. Desired.

In Khyber Pakhtunkhwa province the concentration of iron in water is lower as compared to Sindh and Punjab provinces but still greaterthan the 0.3mg/L WHO limit in many cases.

The industries responsible for iron pollution are steel manufacturing, pipe making and civil engineering or construction (strengthen to concrete, girders etc.).

Cadmium (Cd)

Cadmium is a natural element in the earth's crust. An acute exposure to significantly higher cadmium levels can lead to a variety of negative health effects including Diarrhea, Vomiting, fever, lungs damage, muscle pain(Nordberg, 2004).

While some diseases appear by continuous intake of cadmium, like kidney disorder and bone damage, reproductive problem and possibly even cancer.

(Barbier *et al.*, 2005), (Frery *et al.*, 1993; Johnson *et al.*, 2003; Piasek and Laskey, 1999), (Kazantzis, 1979), (Waalkes *et al.*, 1988).

The permissible value of Cd according to WHO is 0.003 mg/L.

In Pakistan, Cd concentrations in both surface and ground water found higher than the WHO standard limit that may be a result of discharge of untreated waste from industries like marble, steel electroplating (to avoid corrosion), mining, aluminum and most often it is used in the manufacturing of rechargeable nickel-cadmium batteries.

In Khyber Pakhtunkhwa (KPK) province the highest value of 0.021mg/L was detected in the samples taken from well water of Hayatabad Industrial Estate(S. Manzoor *et al.*, 2006)Similarly, in surface water samples from various sites in KPK, Cd concentration reported between 0.002 to 0.09mg/L with mean value of 0.02mg/L. Whereas Cd concentration in Malir River of Karachi city of Sindh province ranged from 0.002 and 0.07mg/L with mean value of 0.04 mg/L.

The highest value of 5.35 mg/L Cd concentration reported in wastewater from Korangi area, Karachi (M. S. Saif *et al.*,2005), which is higher than the permissible limit of 0.10mg/L set by NEQS-Pak for industrial and sewage wastewater. Furthermore, in Lahore city of Punjab province Cd concentration is also higher than the NEQS-Pak safe limit, and ranged from 0.18 to 0.37mg/L (A. Mahmood *et al.*, 2014).

Table 2. Arsenic contamination in various districts/cities of Punjab and Sindh Provinces Source: PCRWR (2008b, c).

City/district name	Total no. of samples	No. of samples >10 µg/L	No. of samples >50 µg/L	% of samples >10 µg/L	% of samples >50 µg/L
Punjab Province					
Bahawalpur	145	35	6	24.13	4.13
Hasilpur	110	9	–	8.18	0
Khairpur	108	6	1	5.55	0.92
Ahmedpur East	185	44	5	23.78	2.70
Yazman	210	44	8	20.95	3.80
Sadiqabad	298	57	9	19.12	3.02
Rahim Yar Khan	302	63	12	20.86	3.97
Khanpur	262	41	5	15.64	1.90
Liaqatpur	254	47	6	18.50	2.36
Multan City	56	40	7	71.42	12.5
Shujaabad	80	34	1	42.5	1.25
Jalalpur Pirwala	103	32	4	31.06	3.88
Sindh Province					
Khairpur	420	56	8	13.1	1.9
Gambat	388	209	102	53.35	26.03
Kotdiji	306	10	2	3.27	0.7
Dadu	595	347	150	58.3	26.55
Johi	140	30	4	21.4	3
Sehwan	139	62	40	44.6	29
Total	1988	563	152	28.3	7.64

Chromium (Cr)

The most interesting thing is that chromium itself not toxic while its important role in our body but some of its compound are toxic. In human body, chromium metal act as an essential part of metabolic processes that regulates sugar level in blood, and helps insulin transport glucose into cells, where it can be used for energy. A very little amount of chromium is needed by our body. Due to its involvement in metabolism of fats, proteins, carbohydrate, carbs and other nutrients, chromium also play a role in preventing cardiovascular disease. Chromium based deficiency include symptoms like, irregular blood glucose, fatigue, high cholesterol, anxiety etc. As compared to trivalent (+3) chromium, hexavalent (+6) chromium is more toxic, and this form results from industrial pollution. And an excess intake of this form may cause irritation of skin, digestive problem and lung cancer. Maximum allowed concentration of Chromium in water according to WHO is 0.05mg/L.PCRWR conducted a study in 23 major cities of Pakistan, and observed that only 1% of groundwater samples crossed the safe limits for chromium (PCRWR,2005). Many researchers reported the concentration of chromium is higher than the WHO safe limit (0.05mg/L). The concentration of chromium reported 9.80mg/L (means 2.12mg/L) in drinking water samples taken from the residential area of Kasur, Punjab province (Tariq *et al*, 2008).Comparably, 25% samples were taken from Karachi (Sindh Province) and 75 % samples were collected from different sources in Khyber Pukhtoonkhwa Province for the analysis of drinking water and observed that chromium concentration exceed the maximum allowed value for drinking water (Midrar-Ul-Haq *et al.*, 2005).

Industrial activities also impact on of heavy metal concentration if they drain their waste without any treatment. In Lahore and Sialkot there are several industries of leather and tanneries that play a harmful effect on health by increasing chromium concentration in the atmosphere (Ullah *et al.*, 2009).

Table 3. Comparison of advantages and disadvantages of various treatment techniques accessible for the removal of heavy metals from wastewater.

S.NO	Techniques	Advantages	Disadvantage	References
1	Coagulation	Cost effective, Dewatering qualities	Generation of sludge, Utilization of chemicals is high	M.J.K. Ahmed, *et al.*, (2016).
2	Membrane filtration	High removal of heavy metals, lower space requirement	Very expensive, membrane fouling, complex process.	M.J.K. Ahmed, *et al.*, (2016).
3	Adsorption	Easy operation, less sludge production, utilization of low cost adsorbents	Desorption	L. Ruihua *et al.*, (2011) .
4	Electrochemical treatment	Efficient for the removal of important metal ions, low chemical usage	Initial investment is high, need high electrical supply	M.J.K. Ahmed, *et al.*, (2016).
5	Electrodialysis	High segregation of metals	Clogging and energy loss	T.A.H. Nguyen, *et al.*, (2013).
6	Ion exchange	High transformation of components	Removes only limited metal ions, operational cost is High	U. Farooq, *et al.*, (2010).
7	Photocatalysis	Eliminates both the metal ions and organic pollutants concurrently	It takes prolonged time to remove the metals	Ihsanullah *et al*,.(2016).
8	Biological treatment	This technology is beneficial in removing heavy metals	Need to be developed	M. Ahmaruzzaman, *et al.*, (2009).
9	Oxidation	No need of electricity	Rusting occurs in the system due to the usage of oxidation	D.S. Patil, *et al.*, (2016).

Nickel (Ni)

Nickel is a metal that occurs in the environment, and can be found in air, water and soil. Yes, we have requirement for Nickel, not much but in a trace level. The exact reason why we need this mineral is not clear. According to animal studies nickel play a role in use of folic acid and vitamin B12 by human body. Some other animal studies also suggest that Nickel concentration influence the production of certain hormones. An uptake of excess quantities of nickel can lead to adverse health effects such as lung cancer, nose cancer, larynx cancer and prostate cancer, Sickness, dizziness, Asthma and Heart disorders. Humans are exposed to Nickel by breathing Ni contaminated air, drinking water, eating food. WHO permissible value for Nickelis 0.02mg/L, this amount is not harmful for our body. In Pakistan the concentration of nickel in ground and surface water ranges from 0 to 3.66 mg/L and 0 to 1.52 mg/L respectively (Table1). A relative study shows that the Ni concentration in Khyber Pakhtoonkhwa Province have much higher concentration of nickel (0.002-3.66mgL) as compared to Karachi (Sindh Province) where its range is(0.01-2.19mg/L) Midrar-Ul-Haq *et al.*, 2005).In most cases nickel concentration in ground as well as in surface water under WHO acceptable limit.

Lead (Pb)

Lead is toxic heavy metal and it is found in the earth crust (Raviraja *et al.*, 2008). There are too many source that introduce lead in atmosphere such as Industrial waste, household paint, and vehicle exhausts (Nadeem-ul-Haq *et al.*, 2009). The permissible limit set by WHO for Lead in drinking water is 0.01mg/L. The reported concentration of lead in different areas of Pakistan ranges from 0.001 to 2.0 in groundwater and 0 to 0.38mg/L in surface water (Table 1). The lead concentration is very high in Pakistan even it is higher to an allowable value. In Charsadda and Risalpur (Khyber Pakhtookhwa Province) 88% of water samples and in Karachi Sindh Province) 100% of water samples exceeded the permissible value for lead set by WHO (Midrar-Ul-Haq *et al.*, 2005).Sialkot (Punjab Province) has also alarming condition because 100% sample of water in this region exceeded the critical value of 0.01 mg/L (Ullah *et al.*, 2009).There is no well-known biological function of lead in human body (Raviraja *et al.*, 2008). However, excess amount of lead creates harmful effect on health and it can directly destroy the major organs and system of body. Kidney failure, haematopoietic, cardiovascular diseases, nervous disorder, effect on immunological system these are the most common diseases due to interaction of lead. (Gidlow, 2004; Riess and Halm, 2007; Venkatesh, 2004). In women during pregnancy, even low concentration of lead can effect on the newborn baby, low birth weight and miscarriage (Bellinger, 2005; McMichael *et al.*, 1986). In men high level exposure of lead can damage the organs which produce the sperm.

Mercury (Hg)

Mercury is a naturally occurring metal in the environment. It can be found in metal form, as mercury salts or as organic mercury compounds. It acts like slow poison (persistent bioaccumulative toxin) for the living thing (Weiss and Wright, 2001).Mercury can easily be introduced into atmosphere through various process including human activities and natural process such as normal breakdown of minerals in rocks, fossil fuel combustion, use of agricultural fertilizers and disposal of industrial wastewater (Weiss and Wright, 2001). WHO has suggested a permissible concentration of mercury in drinking water that is 0.001mg/L. Three main reservoirs of water in Pakistan; Lloyd (0.14mg/L), Tarbela (0.014mg/L) and Chashma (0.017) were chosen for Mercury analysis, all of them showed higher concentration of Hg than WHO safe value (Ashraf *et al.*, 1991). There are a few studies available on Hg concentration in drinking water. PCRWR also conducted a study and observed that Hg concentration exceeded the WHO safe limit. Mercury has a number of effects on humans and environment. In the aquatic environment Hg can be transformed into methyl mercury which is the most toxic form of Hg (Fatoki and Awofolu, 2003). Since it is a potential cellular toxin, it can effecton various process within nerve cell. It decreases the production of hormones like thyroid hormones and testosterone in the body also affect nano transmitter production (Fatoki and Awofolu, 2003).

Arsenic (As)

Arsenic is a naturally occurring component of the earth's crust and It is widely dispersed throughout the environment. Arsenic is carcinogenic to humans in its inorganic form. In groundwater it is derived from weathered rocks and soils. Inorganic arsenic from rocks also dissolved in aquatic ecosystems in the form of arsenic trioxide (As_2O_3), arsenopyrite (As FeS), orpiment (As_2S_3), and realgar (As_4S_4).In addition to naturally occurring in the environment, arsenic can be released in higher quantities through volcanic activity, forest fires, and human activity. Industrially, Arsenic is used as an alloying agent, as well as in the manufacturing process of glass, metal adhesives, pigments, paper, wood preservatives and ammunition. Humans are exposed to high levels of inorganic arsenic through drinking contaminated water, eating contaminated food and smoking tobacco. The immediate symptoms of low level arsenic poisoning include vomiting, abnormal heart rhythm, damage to blood vessels, abdominal pain, diarrhea, numbness and muscle cramping. Whereas symptoms responsible for long-term exposure to high levels of inorganic arsenic are usually observed in the skin, and include pigmentation changes, skin lesions and hard patches on the palms and in extreme condition skin cancer, and tumours in kidneys, lungs, bladder, and liver may result. The countries such as Nepal, Bangladesh, Myanmar, India, Vietnam and China have recognized the Arsenic as a big potential risk to public health (Islam-Ul-Haque *et al.*, 2007). The situation is almost same in Pakistan because it has also faced this issue of arsenic contamination. The concentration of Arsenic in drinking water from many areas of Pakistan exceeded the WHO standard limit of 10ppb (µg/L). The observed arsenic concentrations in three main reservoir of Pakistan i.e. Lloyd (620 µg/L), Chashma (750 µg/L) and Tarbela, (620 µg/L) (Ashraf *et al.* 1991) are higher than WHO safe limit. The average arsenic concentration reported in nineties is 80 µg/L in Karachi groundwater (Rahman *et al.*, 1997). The joined study was designed to predict the arsenic concentration in drinking water between Pakistan Council of Research in Water Resources (PCRWR) and Unites Nation Children Fund (UNICEF) in 2000.The arsenic was identified in Rawalpindi District and Attok. Some studies also conducted by PCRWR to point out presence of arsenic concentration in the different area of Pakistan, with the help of this study various areas of Punjab and Sindh were investigated for Arsenic concentration. (Table 2).If we discussed Multan (Punjab), Dadu and Ganbat(Sindh), in these areas more than 50% of water sample are beyond the standard limit of 10 µg/L, the situation is more annoying in some areas where concentration of arsenic reported above 50 µg/Land in Sindh it exceeded to 200 µg/L (PCRWR, 2008b).

Water Treatment Techniquesor Removal of Heavy Metal from Water

As we know world grows fastly and science plays the important role. Industries are also the part of science and Technology. There are so many different technologies use to remove pollutant each technology has certain advantage and disadvantage. Ion exchange, super critical fluid extraction, adsorption (S.O. Lesmana *et al.*, 2009), electrodialysis, filtration, precipitation (Y. Huang *et al.*, 2015), the electrochemical process, microbial system (M.J.K. Ahmed *et al.*,2016),membrane bioreactor and an advanced oxidation process (J. Hazard. Mater *et al.*,2014), many techniques are available to remove heavy metal in water and advantages and disadvantages of each technique are describe into (table 3) to affectively remove heavy metal sometime use no of technique at a time. We Classified into three categories chemical, biological and physical.

Coagulation/Flocculation Technique

Treatment of heavy metal in the low soluble compound like hydroxide, carbonates and sulfides is called flocculation and its present alternative method (M. Visa *et al.*, 2016). When we talk about those suspension molecules whose density are equal to the density of water such type of colloidal compounds are not settle down(D. Ghernaout *et al.*, 2015). There are different types of coagulants and each coagulant has it certain quality, effectiveness depends on these factors: PH, mixing condition, temperature and alkalinity. Coagulant compound like aluminium sulphate, ferric sulphate and ferric chloride and derivatives of these like poly ferric chloride and poly aluminium chloride were normally used as coagulants in wastewater treatment process. In coagulation solution. Agglomerates are used to form big colloidal compound than with the help of filtration large compound separate. Oily wastewater treat by poly aluminium zinc silicate chloride, the removal turbidity and COD is about 98.9% and 71.8% respectively (M. Han *et al.*, 2013). Oil removal efficiency in wastewater increase with the help of anionic poly acrylamide (M. Han *et al.*,2013, Yan *et al.*,2010). Aluminum and ferric salt help to remove arsenic and antimony. In coagulation process aluminium and ferric salt remove arsenic while in antimony use less dosage of ferric coagulant. It destabilizes the colloidal particles by neutralizing them and brings settling. Finally, the colloidal particle settles on the metal surface and form precipitation. The disadvantage of coagulation process, it forms a great amount of sludge due to usage of chemical for the separation process. Soluble polymeric flocculants use instead of inorganic reagent because of its environment-friendly, it is soluble in water that's why it forms less slurry, easily available, sulfonic acid and carboxylic acid are the examples of the soluble polymer. (Yan *et al.*,2010, Y. Huang *et al.*,2016). The heavy metal colloids present in water readily convert into precipitate by using nanoparticle followed by Smoluchowski coagulation theory (W. Tao et al., 2016). The nano coagulant (Silver nanoparticle) also deposit heavy metal, it may also decrease TOC concentration in wastewater(W. Tao et al.,2016).Heavy metal like chromium, zinc, nickel, cadmium and lead can separate in a large amount of sediments flocks in wastewater by using coagulants like alum, iron followed by coagulation process (Econ. Environ. Stud *et al.,* 2016). Coagulation/flocculation process effectively separate heavy metal but on the other hand, it also produces flocks as a byproduct (secondary pollutant) it contains heavy metal and also has little amount of coagulant material. (J. Clean. Prod *et al.*, 2016).

Ion Exchange Separation Technique

Ion exchange separation, in which one of an ion is substitutes to another ion that is present in wastewater. In ion exchange, there is less amount of sludge formation as compared to coagulation process (J.A. Shah, T. Ashfaq *et al.*, 2013). The separation depends on ion exchange resin quality, based on the chemical property. Mainly two types of resins, synthetic and natural resin (J.A. Shah, T. Ashfaq *et al.*, 2013). Synthetic resin gives a much better result as compared to natural one. Arsenic is removed with the help of synthetic resin, it is the application of synthetic resin (B. An, Q. Liang *et al.*, 2011). In each type of the resin are further divided into two types, Cation and anion exchange resin. For removal of metal use cation resin. Zeolite has the maximum capacity to adsorb metal in wastewater, many researchers also concluded this property of zeolite (T. Motsi *et al.*, 2009).The zeolites structure is a crystal that contains silicate and aluminium which is connected by oxygen bridges. In zeolites the Ion exchange efficiency increase with these alkaline charge balancing cation $Na+$, $K+$, $Ca2+$, $Mg2+$ these ion connected to electrostatically with Al (H. Figueiredo *et al.*, 2014). Zeolites resin commonly uses to remove heavy metals like Ni, Cu, Cd, Pb, Zn in industrial water (H. Figueiredo *et al.*, 2014),(B. Alyuz, S. Veli *et al.*, 2009),(H.S. Jamil *et al.*, 2010). Secondary pollution produces due to Re-formation (recharge) of resin and also require the reagent that also increase water treatment cost. Ion exchange is suitable for low pollutant water. It mostly uses in laboratory purpose, at large scale, it increases the cost of water treatment (M. Bilal, J.A. Shah *et al.*, 2013)In 1995 magnetic ion exchange use as ion exchange resin, it was used to remove natural matter (R.D. Ambashta, M. Sillanpaa *et al.*,2010).

Flotation Technique

Flotation Technique is a separation technique in which solid particle like metal separate into liquid, in this process small droplet introduce into waste water and the heavy metal eliminate by the adsorption on foam. These water foams are formed at the top of the layer which is easily removed by applying another process. It is the process to removes heavy metal in water because it forms a very low amount of sludge but its separation ability is high.it is great potential towards those compound which has to alter physical and chemical nature (M.R. Mahmoud, N.K. Lazaridis *et al.*,2014). The parameter of flotation process is bubble formation frequency, bubble size and bubble velocity (D.S. Patil, S.M. Chavan *et al.*, 2016). Operation cost and maintenance are high in the flotation process.

Filtration Technique

Membrane filtration is one of the best filtration because with the help of the process we can remove heavy metal as well as destruct other harmful microorganisms (S. Lyu, W. Chen *et al.*, 2015). There is many factor that depend on membrane filtration, particle size, pH solution concentration and applied pressure (M.A. Barakat, E. Schmidt *et al.*, 2010). The membrane is made up of porous material, this helps to separate metal from pollutant water (D.S. Patil, S.M. Chavan *et al.*, 2016). There are two types of ceramic and polymer. The ceramic membrane provides effective result in the separation of heavy metal in industrial wastewater as compared to polymer membrane (N.S.A. Mutamim *et al.,* 2012). Ceramic material membrane are high in cost and it is also weak (N.S.A. Mutamim *et al.*, 2012). Membrane filtration also remove other Organic compound and suspended material.

Chemical Technique

The chemical precipitation (separation) method is one the most common method which is used in many industries because it is the comparably cheap coast. By changing the pH metal precipitate form and not dissolve in a solution (M.A. Hashim, S. Mukhopadhyay *et al.*, 2011). Metal is extracted by sentimental process (F. Fu, Q. Wang *et al.*, 2011). Isolated of heavy metal like Cu+2, Cd+2, Mn+2, and Zn+2 (K. Tanong *et al.*, 2017). We can eliminate nickel and manganese by using sodium carbonate at pH 9. This method is suitable for higher concentration level of Ni while it does not suitable for Mn at low concentration in wastewater (Y.C. Kuan, I.H. Lee, J.M. Chern *et al.*,2010).

Electrochemical Treatment

Removal of heavy metal by electrochemical treatment, metals are moves towards their respective electrode that result separation has done (C. Trellu, E. Mousset *et al.*, 2016). Electrochemical treatment ability depends upon some factor like electrode material, mass transport, cell parameter, water composition and current density (C.C. de Almeida, P.R.F. da Costa *et al.*, 2014). The demand of electrochemical treatment increase for the treatment of water day by day as we understand the importance of environment pollution. When we compare electrochemical treatment to other treatment like Coagulation method, Chemical treatment method it is much better because it does not produce any side product. The disadvantage of electrochemical treatment is that it requires large amount of energy and as well as require high maintenance and it is also limited application due to the lifetime of electrode material is short (C. Zhang, Y. Jiang *et al.*, 2013). This technique eliminates very low amount of heavy metal which is present in water due to this we can also say that its secondary treatment method. It works as secondary treatment process in front of ion exchange or precipitation treatment process (X.T. Le, P. Viel, A. Sorin *et al.*, 2009), (H. Cui, Y. Qian *et al.*,2012).

Adsorption

It is a very common process to the treatment of wastewater. It is the cheapest method because the adsorbent of this process recharged (desorption) by several methods, which is environment-friendly like Thermal regeneration, electrochemical regeneration, pressure swing. This technique does not produce any toxic pollutant (A. Demirbas *et al.*, 2008). It is the most popular technique for a treatment of wastewater. By the selection of adsorbent consider some qualities such as less in cost, surface area pore size etc. Some factor also affects the efficiency of adsorbent like polarity, pore size distribution, surface area (E. Vunain *et al.*, 2016), (A. Ewecharoen *et al.*, 2009).

Conclusion

Healthy Water is a basic need for life. Now at this time, Science able to detect contaminated and healthy water. The excess amount of heavy metal present as pollutant in unhealthy water. Many researches and observations proved that at higher concentration of heavy metal, many organs of the living thing can be damagedand it cause serious diseases. Water Contamination mostly due to wrong human activities either in the industrial or residential way. Luckily men able to control these serious diseases by removing excess amount of heavy metal in drinking water. There are lots of water treatment techniques developed to remove heavy metal in water like coagulation, chemical, membrane, electrochemical, adsorption and so on.

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