**Supplementary Table 1**: Heavy metals contamination in the cigarettes brands

| **Country** | **Year** | **Experiment type/analytical method** | **Heavy metals analyzed** | **Finding** | **Reference** |
| --- | --- | --- | --- | --- | --- |
| Bangladesh | 2023 | Atomic absorption spectrophotometry (AAS) | Pb, Cd, Co, Cu ,Ni, Fe, Cr, Mn, As and Zn | The carcinogenic risk posed by heavy metal follow the order of Cr $>$Co$>$ Cd $>$As $>$Ni$>$ Pb. | (Hasan et al., 2023) |
| Benin and France | 2013 | AAS | Pb, Cd Ni and As | The results show that all the cigarette samples are contaminated with lead (Pb), Cadmium (Cd), Nickel (Ni) and Arsenic (As). | (Agbandji et al., 2013) |
| Brazil | 2011 | Graphite furnace atomic absorption spectrometry (GFAAS) | Pb, Cd, As, Ni and Cr |  large variability in the levels of carcinogenic heavy metals in cigarettes, reaching up to 44.1% in the level in Cd. | (Viana et al., 2011)  |
| Brazil | 2007 | Inductively coupled plasma optical emission spectrometry (ICP-OES) | Al, Ba, Ca, Cu, Fe, K, Mg, Mn, Na, P and Sr | Ca, K, Mg, and P are the major elements in all samples. Al, Fe, and Na are elements with an intermediate content. | (CRISPINO et al., 2007) |
| Brazil | 2021 | Square wave Anodic stripping Voltammetry | Cd, Pb and Cu | The detection limit where in order of Cd$<$ Pb $< $Cu. | (Lisboa et al., 2021) |
| Brazil | 2020 | Electrothermal vaporization–atomic absorption spectrometry (EV-AAS) | Cr | The average Cr values found for the analyzed samples were in the range of 0.96 to 3.85 and from 0.32 to 0.80 μg/cigarette for tobacco and ashes, respectively. | (Lisboa et al., 2020) |
| Bulgaria | 2023 | AAS  | Mn, Zn, Cu, Cd, Pb, and Ni | The average concentration of HMs in the RYO/MYO tobaccos blends was in the order Mn > Zn > Cu > Pb > Ni > Cd; respectively. | (Peeva et al., 2023) |
| China | 2014 | X-ray Fluorescence (XRF) | As, Cd, Cr and Pb | On average, from 2009 to 2012, As, Cd, Cr and Pb concentrations have decreased in Chinese tobacco. | (O’Connor et al., 2014) |
| China | 2020 | Indusively couple plasma mass atomic spectrometry (ICP-MAS) | Cd and Pb | The range concentration where in order Pb > Cd | (Li et al., 2020) |
| China | 2016 | GFAAS | Cu, Cd, Cr, Ni and Pb | The average concentration were of order Ni >Cr> Cd> Pb >Cu. | (Ren et al., 2016) |
| China | 2012 | GFAAS | Cd, Cu, Co, Ni, Zn and Pb | The average concentrations were of order of Zn> Ni >Cu >Co >Cd> Pb | (Pourkhabbaz and Pourkhabbaz, 2012) |
| Egypt | 2017 |  Instrumental neutron activation analysis (INAA)  | Ba, Br, Ca, Cd, Eu, K, Hf, Mg, Na Rd, Sb, Sc, Th and Yb.  | The highest Element concentration were Na and lowest were Eu | (Abd El-Samad and Hanafi, 2017) |
| Ethiopia | 2017 | AAS | Cd, Pb, Cu and Zn  | The results indicate that smoking and exposure to cigarette smoke is a serious problem to be considered when carrying out epidemiological studies on human exposure to trace metals. | (Engida, 2017) |
|  Ghana  | 2014 | AAS | As, Ld, Cu, Fe, Znc, Mn, Cd, Ni, and Cr | Estimated the mean of Pb, Mn and Cd was slightly higher than the recommended permissible limits of WHO/FAO/JECFA | (Etsey Sebiawu et al., 2014) |
| Hungary | 2002 | nductively coupled plasma atomic emission spectroscopy (ICP-AES) | Fe, Zn,Pb, and Cd | Fe is found in the highest concentration in tobacco followed in decreasing order by Zn, Pb and Cd | (Csalári and Szántai, 2002) |
| Hungary | 2009 | INAA | As, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, K, La, Na, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, Zn | The highest concentration element was Ar and lowest was Tb | (Hamidatou et al., 2009) |
| India | 2009 | DPASV for Pb, Cd, and Cu; square wave voltammetry for As; and cold vapor atomic absorption technique for Hg. | Pb,Cd, As, Cu,Hg, and Se | It was observed that almost 30% of gutkha brand samples exceeded the permissible levels of metals Pb and Cu, | (Dhaware et al., 2009) |
| India | 2022 | AAS | Cd, Cu, Fe, Pb,Sn, Zn, and Hg. | Findings indicate thatcigarette litter is a major source of metal contamination in the aquatic ecosystem and that apparentleaching may increase the risk of toxicity to aquatic organism | (Michael et al., 2022) |
| India | 2019 | ICP-AES | Cd, Co, Cr, Mo, Cu, Fe,Ni Pb,Ca, K, Mg, P, and S | The highest element concentration range were iron and lowest were Mo. | (Özcan et al., 2019) |
| India | 2010 | ICP-AES | Cd, Ni, Pb, Cr, Cu, Fe and Zn | The highest concentration element were Fe and lowest were Cd | (Verma et al., 2010) |
| Iran | 2016 | FAAS | Cd and Pb | Below the world standards for human consumption by plant. | (Ziarati et al., 2016) |
| Iran | 2015 | SPSS | Cd and Pb | Smoked cigarette filter have more concentration of Cd and Pb than non-smoked cigarette filter | (Pashapour et al., 2015) |
| Iran | 2019 | GFAA | Cd | Mean concentrations of Cd in imported cigarettes brands and cigarettes produced in Iran were 1.89 µg/g and 1.44µg/g respectively | (Ziyae Aldin Samsam Shariat et al., 2019) |
| Iraq | 2015 |  FAAS | Pb ,Cd and Cr | The investigation confirmed that most of the Iraqi and imported cigarettes in Iraq are contaminated with Pb, Cd, and Cr and quantitatively their distribution is clearly above the safer limits of WHO | (Karbon et al., 2015) |
| Iraq | 2020 | FAAS | Pb and Cd |  Generally, it has been found that the concentration of the studied heavy metals in the tobacco follows the order Pb > Cd | (Khleif et al., 2020) |
| Iraq | 2021 | FAAS | Cd, Cr, Pb and Zn | The total value of these four metals ishigher than the range of cancer risk specified by USEPA. | (M. Haleem and A. Amin, 2021) |
| Iraq | 2022 | ICP-AES | Na, P, K, Fe, Cu, Zn, Sr, Cd, Sn, and Ba | The element were of following order: K> P > Fe > Na > Sr > Sn > Zn > Ba > Cu > Cd | (Joda and Alheloo, 2022) |
| Iraq | 2015 | AAS | Cd, Ni, Cu, Fe, Zn and Pb | It was found that all the elements are found in cigarette tobacco according to the following order Fe>Zn>Cu>Pb>Ni>Cd | (Al-Jeboori et al., 2015) |
| Iraq | 2020 | FAAS | Cd, Pb, Cr and Zn | The average concentration of where in order of Pb > Cr >Zn >Cd  | (Haleem et al., 2020) |
| Iraq | 2018 | Energy dispersive X-ray fluorescence (EDXRF) | Sb, Ni, Zn, P, Pb, Cd, Ca, Si, S, Cr, Mg, Na, As, Al, Cl, and Sn. | Results proved the presence of dangerous elements such as Ni, Zn, P, Pb, Cd, Si, S, Cr, As, Al, Sb and Sn | (Al-Dahhan et al., 2018) |
| Ireland | 2015 | ICP-AES | As, Al, Ni and Pb | Mean concentration were in order of Al >Ni> Pb> As. | (Afridi et al., 2015a)  |
| Ireland | 2015 | ICP-AES. | As, Cd, Hg, and Pb | The average concentration of were in order of Hg> Cd> Pb> As | (Afridi et al., 2015b) |
| Japan | 2021 | GF-AAS | Pb,Hg and Cd | The average concentration are in order Pb> Cd > Hg | (Dinh et al., 2021) |
| Jordan | 2005 | GF-AAS | Cd and Pb. | The concentration were of order Pb >Cd | (Massadeh et al., 2005) |
| Jordan | 2003 | AAS | Cu and Zn | Concentration were in order Cu >Zn | (Massadeh et al., 2003) |
| Jordan  | 2003 | FGFAAS | Cd, Pb, Cu, Zn, and Fe | High concentration were of Pb and Cd | (Jaradat et al., 2003) |
| Kenya | 2015 | AAS | Pb, Cd, Cr, Cu and Zn | The primary heavy metal component in all the cigarette brands investigated was Pb while Cd was detected in low amounts | (Omari MO et al., 2015) |
| Kenya | 2020 | AAS |  Cd, Zn and Pb | The concentration were of the order Pb >Zn> Cd | (Peter et al., 2020) |
| Malaysia | 2017 | XRF | As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, and Zn | The highest element detected was Fe and elements with low concentration were Ni | (Ismail et al., 2017) |
| Malaysia | 2019 | AAS | Pb and Cd | The average concentration were of order Pb> Cd | (Janaydeh et al., 2019) |
| Mexico | 2008 | Total X-ray fluorescence (TXRF) | Cd and As | The average concentration were of order of Cd >As | (Martínez et al., 2008) |
| Nigeria | 2017 | FAAS | Cd, Cu, Fe, Mn, Pb, and Zn |  Concentrations of heavy metals in the filler tobacco samples were consistently higher than those obtained for the cigarette filters except for Cd. | (Benson et al., 2017) |
| Nigeria | 2013 |  AAS | Cr, Cd and Pb | The level of Cr, Cd and Pb in selected cigarettes and tobacco leaves were found to be below the WALOH standards for human consumption an plant uptake.  | (Eneji et al., 2013) |
| Nigeria | 2019 | AAS | Zn, Cd and Pb | Concentration of metals in both cigarette brands group follows almost the same trend: Zn > Cd > Pb. | (Onojah et al., 2019) |
| Nigeria | 2011 | AAS | Cd, Cu,Zn, Cr and Ni | Zn concentration was highest in all the brands compared to the other metals; while Cd concentration was lowest in all the ten brands of cigarette analyzed | (Anhwange and Yiase, 2011) |
| Nigeria | 2019 | AAS | Cr, Cd and Pb | The concentration ranges of Cr and Cd in the samples are 60-100 µg/g and 4-20 µg/g respectively, which was found to be lower than the WHO standard. | (Azeez et al., 2019) |
| Nigeria | 2015 | AAS | Cd, Co, Cu, Pb, Ni, and Zn | The mean concentration were of order Zn> Pb> Cu >Co> Ni >Cd | (Yebpella and Shallangwa, 2015) |
| Nigeria | 2013 | INAA | Br, Sb, Sc, Ba ,Hf, Eu, Yb ,Th, As, Na, K ,Ca, Rb, Mg, Al, Mn, La, Sm, Lu, Cs, Ce, Ti, Ta, V, Cr ,Dy, Mn, Cu, Zn, Se and Ni.  | The concentrations of these elements in the analyzed samples range from 0.01 - 2929ppm while Lu, Cs, Ce, Ti, Ta, V and Dy were found below the detection limit of the instrument | (Yebpella et al., 2013) |
| Nigeria | 2014 | GFAAS | Cd ,Co, Cu, Cr, Pb, Ni and Zn | The range concentration were of order Cu> Pb> Cd >Ni> >Co >Cr | (Iwegbue, 2014) |
| Nigeria | 2010 | INAA | Mn, La, Th, Eu, and Hf  | The mean concentration are order of Mn> La >Hf >Th> Eu | (Yebpella et al., 2010) |
| Nigeria | 2013 | AAS | Cd, Cr, Ni Cu and Zn | Generally the levels of content of the metals in all the brands except Zinc were high compared with the WHO threshold values.  | (IWUOHA et al., 2013) |
| Nigeria | 2009 | AAS | Cr, Mn, Ni, Pb, Zn, Cd, Cu, and Co | levels of some toxic heavy metals and pollution index were higher in unashed cigarettes than in ashes | (Asubiojo et al., 2009) |
| Nigeria | 2015 | AAS | Fe,Ca, Zn, Cd, Co and Ni | The average concentration were in order of Fe >Zn > Ca >Co > Ni > Cd | (Abudu et al., 2015) |
| Nigeria, UK, USA and Germany  | 2005 | AAS | Cd | Higher Cd concentrations were found in imported brandscompared to the Nigerian brands. | (Nnorom et al., 2005) |
| Pakistan | 2008 | FAAS | Co, Cu, Cd,Mn,Pb and Zn | The highest concentration element were Mn and lowest were Cd | (Ajab et al., 2008) |
| Pakistan | 2011 | AAS | Ni, Mn, Cu, Cr, Fe, Zn, Co and Cd | Average concentrations of Fe and Mn in locally cigarette brands were found having excess values while Co, Zn, Ni, Cu and more toxic Cd have very small values | (Ahmad et al., 2011) |
| Pakistan | 2017 | AAS | Cd and Zn | Quantitatively allocation is above the tolerable limits as depicted by the WHO | (Asim et al., 2017) |
| Pakistan | 2009 | AAS |  Cu, Mn, Ni and Zn | The mean range concentration were of order Mn >Zn> Ni >Cu | (Siddiqui et al., 2009) |
| Pakistan | 2020 | Particle-induced X-ray emission (PIXE) | S, Cl, K,Ca, Sr Cr, Sb, Hg, Cd, Pb, Zn, Fe Mn, Ni Cu and Co. | The element arranged in order of dencrease their Mean concentration as follows K, Ca, S, Cl, Fe, Mn, Sr, Zn, Cu, Ni, Pb, Cr, Cd, Sb and Hg. | (Mahmood et al., 2020) |
|  Pakistan | 2009 | Electrothermal Atomic Absorption Spectrometry (ETAAS) |  Al, Cd, Ni and Pb | The highest concentration element were Al and lowest was Cd. | (Kazi et al., 2009) |
| Pakistan | 2024 | AAS | Cd, Pb, Cr, Mn, Fe, Co, Ni, Cu and Zn |  The highest concentration element was Zn and lowest was Cd | (Hussain et al., 2024) |
| Palestine | 2015 | FAAS  | Cd, Pb, Co, Ni, Cu and Zn | The average concentration where in order of Cd$<$ Pb$<$ Co $<$Ni $<$Cu $<$ Zn | (Abu-Obaid et al., 2015) |
| Philippines | 2013 | FAAS | Pb, Cr and Cd | Cd in the cigarettes tested when ingested did not exceed the safety limit in blood | (Solidum, 2013) |
| Poland | 2021 | N.A | Cd, Hg  | The average concentration were of order Cd> Hg | (Tyka and Rusin, 2021) |
| Poland | 2008 | AAS | Pb,Cd | The average concentration were of order Pb $<$Cd |  (Galażyn-Sidorczuk et al., 2008) |
| Portugal | 2017 | ICP-MS  | Co, Cd, Pb, As and Ti | The highest transfer rate from tobacco to cigarette smoke was found for Ti and lowest were As. | (Pinto et al., 2017) |
| Romania | 2014 | AAS | Cd, Pb, Cr, Ni, Cu and Zn, | Highest Concentration level was recorded in Cu, followed in descending order by Cr, Pb, Zn, Cd and Ni. | (AGOROAEI et al., 2014) |
| Romania | 2018 | GF-AAS | Cd, Ni, Cu, Cr and Pb | They concluded that the metal content in tobacco depends on factors such as land where the plant was cultivated and manufacturing process used, which requires a series of harmful chemicals. | (Strungaru et al., 2018) |
| Saudi Arabia | 2021 | ICP-OES | Cr, Cd,Cu, Fe, Pb,Mn and Zn | The concentration for both Pb and Cd, the potent human carcigones were greater than the recommended threshold set forth by WHO and FAO. | (Dahlawi et al., 2021) |
| Saudi Arabia | 2012 | GFAAS | Cd and Pb | The concentration were of order Pb> Cd | (Ashraf, 2012) |
| Serbia | 2012 | ETAAS | Pb and As | Positive correlation between lead and arsenic contents in tobacco was found (r=0.22; p<0.0001). | (Lazarević et al., 2012) |
| Spain | 2015 | ICP-OES | Al, Cd ,Co,Cr, Mn ,Ni, Pb and Sr | The means concentration are of order Al >Mn> Sr> Pb> Cr> Cd >Ni> Co | (Armendáriz et al., 2015) |
| Tanzania | 2024 | AAS | Cu, Cd, Cr, Zn and Ni | The means concentration are of order Cu> Cr> Ni> Zn> Cd. | (Ntarisa, 2024) |
| Turkey | 2012 | GFAAS | Cd | Cd levels in tobacco were found between 503-2742 ng/cigarette | (KADIOĞLU et al., 2012) |
| Turkey | 2012 | FAAS | Co ,Ni, Fe, Cu, Mn, Pb, Cr and Cd  | The mean value concentration where in order of Fe> Mn> Cu >Cr> Ni >Pb> Co> Cd. | (Duran et al., 2012) |
| Turkey | 2017 | ICP-OES | Sn, Cd, Pb, Al, Fe, Zn, Cr, Ni, Cu, Mn, As and Hg | It has been reported that one cigarette contains about 0.5- 2 μg of Cd and that about 10% of the Cd content is inhaled when the cigarette is smoked. | (Söğüt and Uruş, 2017) |
| Turkey | 2013 |  Flame atomic absorption spectrometry | Cd, Zn, Cu and Mn | The determined values agreed with the standard values for the heavy metals analyzed | (Pelit et al., 2013) |
| Turkey | 2001 | ICP-MS | Cd,Cr, Co,Ni,Cu,As,HgAnd Pb | The highest concentration element were Cu and lowest were Ni | (Barlas et al., 2001) |
| USA | 2013 | XRF | As, Cd, Cr, Ni, and Pb | Overall, metal concentrations were only weakly intercorrelated. Nickel and chromium concentrations were highly related | (Caruso et al., 2013) |
| USA | 2006 | Gas chromatograph equipped with a flame ionization detector. | Cd, Pb and Th | Mainstream smoke levels of all three metals were far greater for counterfeit than the authentic brands | (Pappas, 2011) |

**Supplementary Table 2** : Heavy metals concentrations of Cd in the cigarettes brands

| **Manufactures country** | **Year** | **N** | **Heavy metal concentrations range (**$μg/g$**)** | **Mean Heavy metal concentrations (**$μg/g$**)** | **Reference** |
| --- | --- | --- | --- | --- | --- |
| Bangladesh | 2023 | 10 | 0.6-3.0 | N.A | (Hasan et al., 2023) |
| Benin | 2012 | 5 | 26.0- 84.8 | 47.2 | (Agbandji et al., 2013) |
| Brazil | 2011 | 20 | 0.5-0.9 | 0.7 | (Viana et al., 2011) |
| Bulgaria | 2023 | 5 | 0.4-1.8 | 0.8 | (Peeva et al., 2023) |
| China | 2017 | 11 | N.A | 0.1 | (Ren et al., 2016) |
| China | 2016 | 20 | 2.9-5.5 | N.A | (Li et al., 2020) |
| China | 2014 | Several | 2.0–5.4 | 3.2 | (O’Connor et al., 2014) |
| Egypt | 2017 | 10 | 2.8-6.4 | 4.4 | (Abd El-Samad and Hanafi, 2017) |
| Ethiopia | 2016 | 11 | 1.3−7.6 | 2.5 | (Engida, 2017) |
| France | 2012 | 3 | 13.3-63.5 | 41 | (Agbandji et al., 2013) |
| Germany | 2005 | 4 | 1.2-2.2 | 1.8 | (Nnorom et al., 2005) |
| Hungary | 2002 | 30 | 0.2-0.3 | 0.3 | (Csalári and Szántai, 2002) |
| India | 2009 | 25 | 0.01-3 | 0.4 | (Dhaware et al., 2009) |
| India | 2022 | 3 | N.A | N.A | (Michael et al., 2022) |
| India | 2019 | 5 | 0.5-0.7 | 0.6 | (Özcan et al., 2019) |
| India | 2010 | 10 | 0.3-0.9 | 0.5 | (Verma et al., 2010) |
| Iran | 2016 | 10 | 1.8-5.4 | 0.6 | (Ziarati et al., 2016) |
| Iran | 2012 | 19 | 1.8-3.2 | 2.7 | (Pourkhabbaz and Pourkhabbaz, 2012) |
| Iran | 2019 | 8 | 1.4-1.6 | 1.6 | (Ziyae Aldin Samsam Shariat et al., 2019) |
| Iran | 2015 | 10 | 0.2-0.5 | 0.4 | (Pashapour et al., 2015) |
| Iraq | 2021 | 25 | N.A | 0.4 | (M. Haleem and A. Amin, 2021) |
| Iraq | 2019 | 25 | 0.0-1.6 | 0.4 | (Haleem et al., 2020) |
| Iraq | 2015 | 20 | 0.1-1.6 | 0.57 | (Karbon et al., 2015) |
| Iraq | 2020 | 9 | 0.02 -0.06 | N.A | (Khleif et al., 2020) |
| Iraq | 2022 | 16 | 0.2-2.0 | 1.6 | (Joda and Alheloo, 2022) |
| Iraq | 2015 | 17 | 0.03-0.5 | 0.1 | (Al-Jeboori et al., 2015) |
| Iraq | 2018 | 3 | <1 | <1 | (Al-Dahhan et al., 2018) |
| Ireland | 2015 | 7 | 0.3-0.6 | 0.4 | (Afridi et al., 2015b) |
| Japan | 2021 | 10 | N.A | 0.9 | (Dinh et al., 2021) |
| Jordan | 2005 | 19 | 2.2 - 3.1 | 2.6 | (Massadeh et al., 2005) |
| Jordan | 2003 | 4 | 0.1-0.4 | 0.3 | (Jaradat et al., 2003) |
| Jordan | 2004 | 19 | 2.2-3.1 | 2.6 | (Massadeh et al., 2003) |
| Kenya | 2015 | 3 | 0.06-0.09 | 0.08 | (Omari MO et al., 2015) |
| Kenya | 2020 | 5 | 0.09-0.2 | 0.1 | (Peter et al., 2020) |
| Malaysia | 2017 | 16 | 0-5.0 | 0.9 | (Ismail et al., 2017) |
| Malaysia | 2019 | 15 | N.A | 0.8 | (Janaydeh et al., 2019) |
| Mexico | 2008 | 9 | N.A | 1.2 | (Martínez et al., 2008) |
| Nigeria | 2017 | 10 | 5.9–7.9 | N.A | (Benson et al., 2017) |
| Nigeria | 2013 | 10 | 0.01-0.014 | 0.01 | (Eneji et al., 2013) |
| Nigeria | 2019 | 5 | 1.0-2.1 | 1.4 | (Onojah et al., 2019) |
| Nigeria | 2013 | 4 | 0.5-0.6 | 0.6 | (IWUOHA et al., 2013) |
| Nigeria | 2011 | 10 | 0.2-2.1 | 1.4 | (Anhwange and Yiase, 2011) |
| Nigeria | 2015 | 7 | 0.12-0.15 | 0.13 | (Abudu et al., 2015) |
| Nigeria | 2019 | 7 | 0.6-4.5 | 1.4 | (Azeez et al., 2019) |
| Nigeria | 2005 | 7 | 0.9-1.9 | 1.3 | (Nnorom et al., 2005) |
| Nigeria | 2011 | 14 | 0.3-0.7 | 0.7 | (Yebpella et al., 2010) |
| Nigeria | 2018 | 5 | 1.0 – 2.1 | 1.4 | (Onojah et al., 2019) |
| Nigeria | 2009 | N.A | 0.01-2.64 | N.A | (Iwegbue, 2014) |
| Pakistan | 2008 | 10 | 0.3-0.6 | 0.5 | (Ajab et al., 2008) |
| Pakistan | 2011 | 10 | 0.1-0.3 | 0.2 | (Ahmad et al., 2011) |
| Pakistan | 2019 | 19 | 1.9-9.5 | 0.5 | (Mahmood et al., 2020) |
| Pakistan. | 2017 | 9 | 0.04-0.17 | 0.10 | (Asim et al., 2017) |
| Pakistani | 2008 | 12 | 0.3-0.9 | 0.6 | (Kazi et al., 2009) |
| Pakistan | 2024 | 5 | 0.35-0.43 | 0.40 | (Hussain et al., 2024) |
| Palestina | 2015 | 25 | 0.8 - 2.1 | 1.2 | (Abu-Obaid et al., 2015) |
| Philippines | 2013 | 10 | 0.001-0.01 | 0.01 | (Solidum, 2013) |
| Poland | 2019 | 8 | 1.1-1.6 | N.A | (Tyka and Rusin, 2021) |
| Poland  | 2008 | 10 | 0.6–1.4 | 0.8 | (Galażyn-Sidorczuk et al., 2008) |
| Portugal | 2014 | 20 | N.A | 0.8 | (Pinto et al., 2017) |
| Romanian | 2014 | 15 | 0.7-1.6 | 1.1 | (AGOROAEI et al., 2014) |
| Romania | 2018 | 8 | 0.4-1.4 | 0.7 | (Strungaru et al., 2018) |
| Saudi Arabia | 2021 | 20 | 0.2-306.1 | 37.4 | (Dahlawi et al., 2021) |
| Saudi Arabia | 2012 | 20 | 0.8-2.8 | 1.8 | (Ashraf, 2012) |
| Spain | 2015 | 33 | N.A | 0.8 | (Armendáriz et al., 2015) |
| Tanzania | 2024 | 8 | 0.4–0.66, | 0.53 | (Ntarisa, 2024) |
| Turkey | 2013 | 9 | 0.1-0.8 | 0.3 | (Pelit et al., 2013) |
| Turkey | 2012 | 15 | N.A | 1.1 | (Duran et al., 2012) |
| Turkey | 2012 | 20 | 1.0-5.5 | 2.0 | (KADIOĞLU et al., 2012) |
| Turkey | 2017 | 12 | N.A | N.A | (Söğüt and Uruş, 2017) |
| Turkey | 2001 | 9 | 0.5 - 2.6 | 1.7 | (Barlas et al., 2001) |
| U.S | 2013 | Several | N.A | 0.9 | (Caruso et al., 2013) |
| UK | 2005 | 11 | 0.7-2.3 | 1.3 | (Nnorom et al., 2005) |
| U.S | 2005 | 5 | 1.2-1.9 | 1.6 | (Nnorom et al., 2005) |
| U.S | 2007 | 21 | N.A | N.A | (Pappas, 2011) |

**Supplementary Table 3**: Heavy metals concentrations of Pb in the cigarettes brands

|  | Manufactures country | Year | N | Heavy metal concentration range ($μg/g$) | Mean Heavy metal concentration ($μg/g$) | Reference |
| --- | --- | --- | --- | --- | --- | --- |
|  | Bangladesh | 2023 | 10 | 0.5-1.1 | N.A | (Hasan et al., 2023) |
|  | Benin | 2012 | 5 | 1.2-3.9 | 2.0 | (Agbandji et al., 2013) |
|  | Brazil | 2011 | 20 | 0.2-0.4 | 0.3 | (Viana et al., 2011) |
|  | Bulgaria | 2023 | 5 | 0-3.0 | 1.6 | (Peeva et al., 2023) |
|  | China | 2017 | 11 | N.A | 0.2 | (Ren et al., 2016) |
|  | China | 2016 | 20 | 1.3-7.7 | N.A | (Li et al., 2020) |
|  | China | 2014 | Several | 1.2–6.5 | 2.5 | (O’Connor et al., 2014) |
|  | Ethiopia | 2016 | 11 | 0.5−12.5 | 6.2 | (Engida, 2017) |
|  | France | 2012 | 3 | 4.3-4.5 | 4.4 | (Agbandji et al., 2013) |
|  | Ghana | 2014 | 10 | 1.5-8.3 | 5.8 | (Etsey Sebiawu et al., 2014) |
|  | Hungary | 2002 | 30 | 0.3-0.8 | 0.5 | (Csalári and Szántai, 2002) |
|  | India | 2009 | 25 | 0.03-68 | 7.4 | (Dhaware et al., 2009) |
|  | India | 2022 | 3 | N.A | N.A | (Michael et al., 2022) |
|  | India | 2019 | 5 | 0.2-7.4 | 3.5 | (Özcan et al., 2019) |
|  | India | 2010 | 10 | 0.8-5.8 | 1.9 | (Verma et al., 2010) |
|  | Iran | 2016 | 10 | N.A | 34.4 | (Ziarati et al., 2016) |
|  | Iran | 2012 | 19 | 1.1-3.1 | 2.1 | (Pourkhabbaz and Pourkhabbaz, 2012) |
|  | Iran | 2015 | 10 | 16.6-33.5 | 22.3 | (Pashapour et al., 2015) |
|  | Iraq | 2021 | 25 | 1.2-9.3 | 4.6 | (M. Haleem and A. Amin, 2021) |
|  | Iraq | 2019 | 25 | 1.2-9.3 | 4.6 | (Haleem et al., 2020) |
|  | Iraq | 2014 | 20 | 2.3-11.7 | 5.9 | (Karbon et al., 2015) |
|  | Iraq | 2020 | 9 | 0.1-0.2 | N.A | (Khleif et al., 2020) |
|  | Iraq | 2015 | 17 | 0.1-0.4 | 0.2 | (Al-Jeboori et al., 2015) |
|  | Iraq | 2018 | 3 | <1 | <1 | (Al-Dahhan et al., 2018) |
|  | Ireland | 2015 | N.A |  0.378 - 1.16 | N.A | (Afridi et al., 2015a) |
|  | Ireland | 2015 | 7 | 0.2-0.5 | 0.4 | (Afridi et al., 2015b) |
|  | Japan | 2021 | 10 | N.A | 1.6 | (Dinh et al., 2021) |
|  | Jordan | 2005 | 19 | 2.1 - 3.2 | 2.7 | (Massadeh et al., 2005) |
|  | Jordan | 2003 | 4 | 0.2-0.3 | 0.3 | (Jaradat et al., 2003) |
|  | Jordan | 2004 | 19 | 2.1- 3.2 | 2.7 | (Massadeh et al., 2003) |
|  | kenya | 2015 | 3 | 6.6-7.1 | 6.8 | (Omari MO et al., 2015) |
|  | Kenya | 2020 | 5 | 0.1-0.3 | 0.2 | (Peter et al., 2020) |
|  | Malaysia | 2017 | 16 | 0-2.7 | 0.6 | (Ismail et al., 2017) |
|  | Malyasia | 2019 | 15 | N.A | 3.1 | (Janaydeh et al., 2019) |
|  | Nigeria | 2017 | 10 | 17.2– 74.7 | N.A | (Benson et al., 2017) |
|  | Nigeria | 2013 | 10 | 0.001-0.09 | 0.04 | (Eneji et al., 2013) |
|  | Nigeria | 2013 | 4 | 5.2-8.0 | 22.8 | (IWUOHA et al., 2013) |
|  | Nigeria | 2011 | 10 | 0.2-3.9 | 2.0 | (Anhwange and Yiase, 2011) |
|  | Nigeria | 2011 | 14 | 0.1-2.0 | 10.1 | (Yebpella et al., 2010) |
|  | Nigeria | 2009 | N.A | 0.013-0.63 | N.A | (Iwegbue, 2014) |
|  | Pakistan | 2008 | 10 | 10.2-27.3 | 14.4 | (Ajab et al., 2008) |
|  | Pakistan | 2019 | 19 | 0.6-1.4 | 1.0 | (Haleem et al., 2020) |
|  | Pakistani | 2008 | 12 | 0.1-0.6 | 0.3 | (Ren et al., 2016) |
| p | Pakistan | 2024 | 5 | 1.8-2.3 | 2.08 | (Hussain et al., 2024) |
|  | Palestina | 2015 | 25 | 2.2 - 5.1 | 3.1 | (Abu-Obaid et al., 2015) |
|  | Philippines | 2013 | 10 | 0.9-1.2 | 1.0 | (Solidum, 2013) |
|  | Portugal | 2014 | 20 | N.A | 0.5 | (Pinto et al., 2017) |
| Poland | 2008 | 10 | 0.7–0.9 | 0.8 | (Galażyn-Sidorczuk et al., 2008) |
|  | Romanian | 2014 | 15 | 2.3-5.2 | 4.2 | (AGOROAEI et al., 2014) |
|  | Roumania | 2018 | 8 | 0.2-0.7 | 0.4 | (Strungaru et al., 2018) |
|  | Saudi Arabia | 2021 | 20 | 0.2-4725.0 | 312.8 | (Dahlawi et al., 2021) |
|  | Saudi Arabia | 2011 | 20 | 1.3-3.6 | 2.5 | (Ashraf, 2012) |
|  | Serbia | 2012 | 20 | 0.02–8.56 | 0.9 | (Lazarević et al., 2012) |
|  | Spain | 2015 | 33 | N.A | 0.6 | (Armendáriz et al., 2015) |
|  | Turkey | 2012 | 15 | N.A | 3.7 | (Duran et al., 2012) |
|  | Turkey | 2017 | 12 | N.A | N.A | (Söğüt and Uruş, 2017) |
|  | Turkey | 2001 | 9 | 0.3- 2.3 | 1.0 | (Barlas et al., 2001) |
|  | U.S | 2013 | Several | N.A | 0.4 | (Caruso et al., 2013) |
|  | U.S | 2007 | 21 | N.A | N.A | (Pappas, 2011) |

**Supplementary Table 4**: Heavy metals concentrations of Cr in the cigarettes brands

|  | Manufactures country | Year | N | Heavy metal concentrations range ($μg/g$) | Mean Heavy metal concentration ($μg/g$) | Reference |
| --- | --- | --- | --- | --- | --- | --- |
|  | Bangladesh | 2023 | 10 | 0.8-1.2 | N.A | (Hasan et al., 2023) |
|  | Brazil | 2011 | 20 | 0.5-3.1 | 1.4 | (Viana et al., 2011) |
|  | Brazil | 2020 | 12 | 0.3-0.8 | 0.6 | (Lisboa et al., 2020) |
|  | China | 2017 | 11 | N.A | 0.1 | (Ren et al., 2016) |
|  | China | 2014 | Several | 0.0–1.0 | 0.6 | (O’Connor et al., 2014) |
|  | Ghana | 2014 | 10 | N.A | 4.3 | (Etsey Sebiawu et al., 2014) |
| Hungary | 2009 | 5 | 2.4-29.3 | 8.4 | (Hamidatou et al., 2009) |
|  | India | 2019 | 5 | 1.1-1.7 | 1.4 | (Özcan et al., 2019) |
|  | India | 2010 | 10 | 2.8-5.0 | 4.1 | (Verma et al., 2010) |
|  | Iraq | 2021 | 25 | N.A | 3.3 | (M. Haleem and A. Amin, 2021) |
|  | Iraq | 2020 | 25 | 0.0-6.7 | 3.3 | (Haleem et al., 2020) |
|  | Iraq | 2014 | 20 | 0.0-11.2 | 3.8 | (Karbon et al., 2015) |
|  | Iraq | 2018 | 3 | <1 | <1 | (Al-Dahhan et al., 2018) |
|  | Kenya | 2015 | 3 | 1.6-3.6 | 2.8 | (Peter et al., 2020) |
|  | Malaysia | 2017 | 16 | 12.1-50.9 | 22.1 | (Ismail et al., 2017) |
|  | Nigeria | 2013 | 10 | 0.02-0.3 | 0.12 | (Eneji et al., 2013) |
|  | Nigeria | 2013 | 4 | 16.9- 26.0 | 21.6 | (IWUOHA et al., 2013) |
|  | Nigeria | 2011 | 10 | 0.9-3-8 | 2.2 | (Anhwange and Yiase, 2011) |
|  | Nigeria | 2018 | 7 | 4.4-7.9 | 6.4 | (Azeez et al., 2019) |
|  | Nigeria | 2009 | N.A | 0.013-0.013 | N.A | (Iwegbue, 2014) |
|  | Pakistan | 2024 | 5 | 10-14 | 11.2 | (Hussain et al., 2024) |
|  | Romanian | 2014 | 15 | 1.9-7.0 | 3.8 | (AGOROAEI et al., 2014) |
|  | Romania | 2018 | 8 | 0.7-2.1 | 1.2 | (Strungaru et al., 2018) |
|  | Saudi Arabia | 2021 | 20 | 1.2-4.3 | 1.8 | (Dahlawi et al., 2021) |
|  | Spain | 2015 | 33 | N.A | 1.4 | (Armendáriz et al., 2015) |
|  | Tanzania | 2024 | 8 | 0.69–2.86 | 1.82 | (Ntarisa, 2024) |
|  | Turkey | 2012 | 15 | N.A | 5.0 | (Duran et al., 2012) |
|  | Turkey | 2017 | 12 | N.A | N.A | (Söğüt and Uruş, 2017) |
|  | Turkey | 2001 | 9 |  1.3- 2.2 | 1.6 | (Barlas et al., 2001) |
|  | U.S | 2013 | Several | 0.6-7.5 | 2.4 | (Caruso et al., 2013) |

**Supplementary Table 5**: Heavy metals concentrations of As in the cigarettes brands

| Manufactures country | Year | N | Heavy metal concentrations range ($μg/g$) | Mean Heavy metal concentrations ($μg/g$) | Reference |
| --- | --- | --- | --- | --- | --- |
| Benin | 2012 | 5 | 1.0-95.3 | 37.1 | (Agbandji et al., 2013) |
| Brazil | 2011 | 20 | 0.05-0.13 | 0.09 | (Viana et al., 2011) |
| China | 2014 | Several | 0.3–3.3 | 0.8 | (O’Connor et al., 2014) |
| France | 2012 | 3 | 1.01- 89.55 | 50 | (Agbandji et al., 2013) |
| Hungary | 2009 | 5 | 2.2-6.4 | 3.9 | (Hamidatou et al., 2009) |
| India | 2009 | 25 | 0.1-4.0 | 0.5 | (Dhaware et al., 2009) |
| Ireland | 2015 | N.A | 0.432 - 0.727  | N.A | (Afridi et al., 2015a) |
| Ireland | 2015 | 7 | 0.2-0.3 | 0.2 | (Afridi et al., 2015b) |
| Malaysia | 2017 | 16 | 0-0.2 | 0.03 | (Ismail et al., 2017) |
| Mexico | 2008 | 9 | N.A | 0.6 | (Martínez et al., 2008) |
| Serbia | 2012 | 20 | <0.02–2.04 | 0.2 | (Lazarević et al., 2012) |
| Turkey | 2017 | 12 | N.A | N.A | (Söğüt and Uruş, 2017) |
| Turkey | 2001 | 9 |  0.6- 1.0 | 0.9 | (Barlas et al., 2001) |
| U.S | 2013 | Several | N.A | 0.2 | (Caruso et al., 2013) |

**Supplementary Table 6**: Heavy metals concentrations of Hg in the cigarettes brands

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Manufactures country | Year | N | Heavy metal concentrations range ($μg/g$) | Mean Heavy metal concentrations ($μg/g$) | Reference |
| Ireland | 2015 | 7 | 3.5-5.1 | 4.4 | (Afridi et al., 2015b) |
| Japan | 2021 | 10 | N.A | 12.3 | (Dinh et al., 2021) |
| Malaysia | 2017 | 16 | 0-1.5 | 0.2 | (Ismail et al., 2017) |
| Pakistan | 2019 | 19 | N.A | 0.1 | (Haleem et al., 2020) |
| India | 2009 | 25 | N.A | N.A | (Dhaware et al., 2009) |
| India | 2022 | 3 | N.A | N.A | (Michael et al., 2022) |
| Turkey | 2017 | 12 | N.A | N.A | (Söğüt and Uruş, 2017) |
| Turkey | 2001 | 9 |  0.2 - 0.3 | 0.3 | (Barlas et al., 2001) |
| Poland | 2019 | 8 | 0.2-0.1 | N.A | (Tyka and Rusin, 2021) |

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