Research Article

Appraisement and categorization of compostable and non-compostable plastic bags using HHXRF spectrophotometer, A study on brands in Islamabad

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Abstract

Plastic bags are polymers usually composed of polypropylene, polyethylene and polystyrene. Rapid development in the industrial sector manufacturing plastic bags is imposing tremendous side effects on human health and the environment. Conventional plastic bags are made from recycled or first use, but authorities restricted lightweight plastic bags (thickness of <50µm) with compostable material. This study examines the degradation of plastic bags collected from the markets of different sectors of Islamabad. Many samples (~100) were gathered from the public market. Using a Hands Held X-Ray Fluorescent (HHXRF) spectrophotometer and the standard approach, the study confirmed the proportions, amounts, and patterns of several heavy metals (additives) utilized in the production of both types of bags. The result showed Titanium (Ti), Copper (Cu) and Calcium (Ca) were used in massive amounts, other carcinogenic metals i.e., Mercury (Hg), Arsenic (Ar), Chromium (Cr), Lead (Pb) and Cadmium (Cd) were also detected. Long term exposure to this metal can disrupt living cells. We concluded that because of the photolytic qualities of the additives used in degradable plastic bags when the linkages of polymers are generated, degradable plastic bags may be more dangerous than non-degradable plastic bags.

Keywords: Plastic bags, Plastic Pollution, Hands Held X-Ray Fluorescent, Non-degradable and degradable Bags.

Article History: **Received:** 26 June 2024, **Revised:** 05 August 2024, **Accepted**: 12 August 2024, **Published:** 23 September 2024.

Introduction

Since 1995, numerous geoscientific domains have adopted handheld or portable X-ray fluorescence spectroscopy (pXRF) as a common on-site analytical method. These include industrial minerals, process monitoring, environmental assessments and tidying up, and mineral exploration [1-7]. As plastics are useful in

so many applications, they are being employed in consumer goods in increasing numbers. Consumer goods and packaging made of plastic are often strong, lightweight, cheaper, too. They are used in a wide variety of home products, including packaging, personal hygiene products, and keeping food, chemicals, and other random things in storage stuff like brooms and toys. Seven distinct categories exist, with corresponding resin identification codes, a list of plastics. The various kinds of plastics are: (1) low-density polyethylene (LDPE), (2) Styrofoam (PS), (3) polyvinyl chloride (PVC), (4) high-density polyethylene (HDPE), (5) polyethylene terephthalate (PET), (6) Polypropylene (PP), (7) along with the some other. The codes for resin identification describe various categories of plastics. There is metal in these plastics components like Ti, Zn, Br, Cl and Cr [8].

This research article analyzes compostable (degradable) and non-compostable (non-degradable) waste of plastic present in market of Islamabad, Pakistan.

There are only two marked situations on which HHXRF study can be done.

- On-site, in which no sample preparation can be done or only a simplified way of sample mixing can be done, the result then orients for further investigation.
- Off-site or on-site, which have a complex sample preparation procedure using QA/QC measurements, almost done in laboratories.

Around 46,000 plastic bags end up floating in each square mile of the world's oceans. And plastic bags are in the top 12 items of debris found in marine clean ups. During the 2011 International Coastal Cleanup, volunteers collected 120,450 pounds of bags in the United States, and in, around 5, 712 pounds of plastic bags were collected from Massachusetts alone.

The Environmental Literacy Council, 2009 stated that polyethylene isn't biodegradeable. It can break down into synthetic granules under the exposure of ultraviolet radiation from the sun. But these granules aren't proven to break down completely. Therefore, they may damage wildlife and marine environments. Plastic bag litter has had a major impact on marine ecosystems. Marine animals such as turtles, seals, birds, and whales have been found to suffocate, become entangled in litter, and many have starved to death due to blockages in their digestive systems. In one case, in 2002, a mink whale that was stranded in Normandy was found to have 800g of plastic in its stomach. Owing to fact that plastic waste with unsustainable use, disposal and production has now become a high level transboundary threat for human health, natural ecosystem and sustainability [9-10]. Most of the bio-based components come from naturally occurring sources such polysaccharides, cellulose, and maize starch. They have drawn notice as sources that start to document the changing competition for the production of polymeric materials in the 21st century for a wide range of applications. The mechanism of biodegradation requires the actions of extracellular enzymes within a bacterium to break down a polymer into smaller-than-assimilable products or fragments by attacking the ends of big molecules. Since enzymes cannot break down bigger macromolecules, degradation requires the breakage of polymer fragments into tiny enough chain lengths. The initial stage of polymer biodegradation is called chain cleavage, and it involves breaking apart a large polymer chain into smaller oligomeric pieces. Second, tiny fragments of oligomeric polymers are converted into biomass, which includes raw materials, salts, CO_2, and methane. [11]. The emergence of potential plant-based material rather than this conventional polymeric use. Therefore, this study owns the analysis of toxicity in plastic bags. To

assess the concentration of metals major brands have been chosen which are very common in the targeted area.

Method and Methodology

Sampling and categorization

Samples of plastic bags from different shops of various sectors have been collected. These samples were then brought to the laboratory of Environmental Protection Agency Islamabad for further processing. In laboratory of Environmental Protection Agency Islamabad these samples were classified in three main categories:

- Plastic bags with stamp of D_2w / Recyclable material (Bio-Degradable Plastic Bags).
- Plastic bags without the stamp of D_2w / Recyclable material (Non-Degradable Plastic Bags).
- Paper Bags are classified on the base of color, quality, transparency, prints, texture, strength. For Each Category (Bio- degradable and Non-Degradable and Paper bags) fifty samples were selected for analysis with XRF, showed in Figure 1.

Figure 1: Samples of degradable and non-degradable plastic bags.

Apparatus

The X-MET8000 range of handheld X-ray fluorescence (HHXRF) analyzers delivers the performance required for instant identification of Alloy grade. It also identifies accurate chemistry of different materials i.e. (solid and powder metals, polymers, solutions, soil, ores, minerals etc.,). The instrument is practical, Remote, used friendly and deliver trustable Results which is showed in Figure 2 and its properties are mentioned in Table 1.

Table 1**:** The features of the XRF spectrophotometer.

S/No	Features	Elucidation
1	Rugged	The instrument is splash and dust proof. It is tested to have a large heat sink for optimum stability.
2	Connectors	Connectors (mains, USB, HDMI) safe under plastic cover.
3	Covering	Impact resistant, industrial grade plastic covering.
4	Battery	Up to 10 hours battery life, for constant workflow. Battery charge indicator on battery and on screen.
5	Status Lights	Orange lights indicate when the instrument is ready to measure (in contact with a sample) Flashing red lights indicate when X-rays are being generated.
6	Safety sensors	The instrument cannot take a measurement unless the instrument nose is covered by a sample.
7	Optional window shield	Maximum ruggedness when testing sharp objects (e.g., turnings). Shield decreases the risks of detector damage
8	Screen	4.3” color, touch screen, Easy to read in any kind of light including sunlight.
9	User Interface	It has very large icons which are visible in any light. It can be used with gloves on. Customizable display to show what is important to you (i.e., grade ID, chemistry, pass/fail messages).

Figure 2: Ms 8000 HH XRF

Procedure

The specimen is first folded into as many layers as possible before analysis and is placed on a disk made up of X-ray absorbing material (alloy), the XRF is then placed on the specimen. The folding of specimen is important because during analysis XRF releases X-rays which make a field around the specimen. The area of the field is equal to the area of the X ray absorbing disk on which specimen is placed for analysis. When the nose of XRF is touched with the specimen the orange light turns on indicating that the specimen is right, and the instrument is ready to analyze the specimen. Then the triggered is pressed for 3-5 seconds and the XRF starts analyzing the specimen. The process of analysis of XRF after pressing the trigger is 30 seconds, the countdown timer is displayed on the screen and the red light turns on indicating the release of X-rays (mentioned in Figure 3). When the countdown is over the results appear on the screen in the form of a table with three columns i.e., Parameters, values in ppm and values in +/-. These values are then noted and arranged according to the categories made for study.

Figure 3: Analysis of plastic bag using HH-XRF.

Results and Discussion

For the sake of assessment of both different plastic bags which are degradable and non-degradable, fifty samples of each type (degradable and non-degradable) bags were segregated on behalf of their physical characteristics for examination. Following are the tables of the results of different heavy metals found in both degradable and non-degradable plastic bag samples.

Following are the elements and the patterns and trends of their presence in each category:

1. Alternative abundance of Copper (Cu) and Titanium (Ti).
2. Co-existence of Chromium (Cr) and Lead (Pb).
3. Presence of Calcium (Ca) in abundance in both kinds of samples.
4. Small amount of trace elements i.e., Mercury (Hg) Arsenic (As), Zinc (Zn), Iron (Fe), and Cadmium (Cd).
5. Metals which were analyzed but are not detected due to absence.
6. Alternative abundance of Copper (Cu) and Titanium (Ti).
7. Both copper and titanium are showing alternative abundance that means where Titanium is present in excessive amount the Copper is present in traces and where Copper is massive in quantity the Titanium is scarce. The pattern in which titanium and Copper was found in the samples of degradable and non-degradable plastic bags are shown in Figure 4. and Figure 5, respectively.

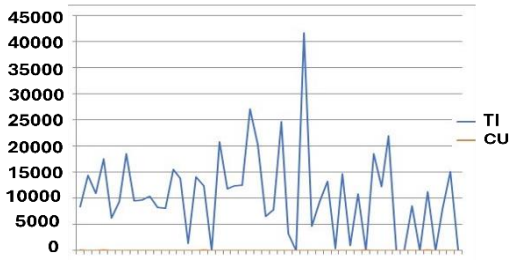

Figure 4: Cu and Ti in degradable plastic bags.

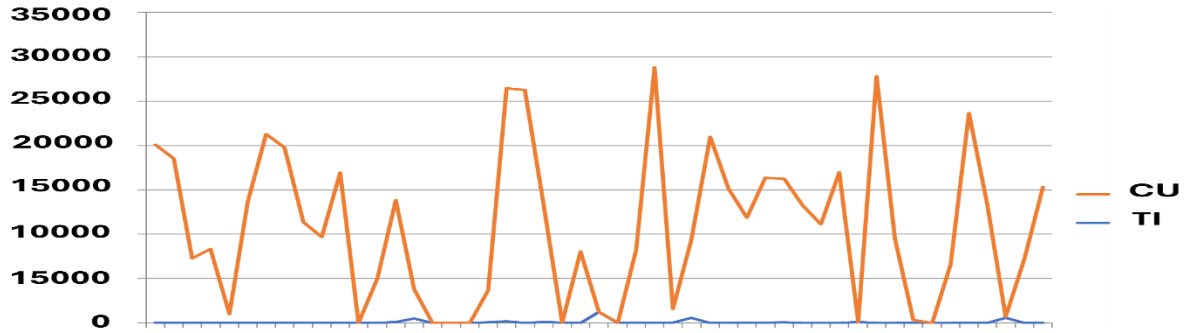

Figure 5: Cu and Ti in non-degradable plastic bags.

Table 2: Degradable plastic bags

S/No	Sample Name	Names of Additives (ppm)									
		Ti	Cu	Ca	Fe	Zn	Hg	Cr	Pb	As	Cd
1	Kohi Noor Jewels	8421	108	7800	54	38	10	0	0	3	0
2	Stylo	14366	0	14002	26	110	0	0	0	2	0
3	Tehzeeb	10987	0	97014	0	79	14	1	0	5	0
4	Habibi	17504	82	26	38	56	0	0	0	3	0
5	Shaheen Chemist	6331	0	126360	94	217	0	1	0	0	0
6	Savor food	9382	0	126708	0	1728	0	1	0	0	0
7	Servis	18572	0	16944	50	215	0	0	0	0	31
8	La Madeleine Bakery	9578	0	121408	101	383	0	0	0	0	0
9	MCC	9698	0	100515	93	211	0	0	0	0	0
10	Fresco	10436	40	109917	122	350	14	0	0	0	0
11	Save Mart	8231	0	146613	0	251	0	10	69	0	0
12	Local White torn	8147	0	167630	122	503	26	0	0	0	0
13	The body shop	15608	0	15643	29	227	10	0	0	4	0
14	Mother care	13866	0	71318	97	463	12	0	0	0	26
15	Jelly Factory	1467	0	33	0	48	27	0	0	2	0
16	Reader's Point	14129	0	133870	146	772	0	0	0	0	0
17	Cinnabon	12472	74	25524	35	94	11	0	0	3	0
18	Cambridge	0	16	22791	33	171	0	0	0	2	0
19	1 Step	20905	0	443	27	41	0	0	0	0	0
20	Local (dense) White	11823	0	92720	0	975	0	0	0	0	0
21	D-Watson	12359	0	131150	93	656	17	0	0	0	0
22	Vincci	12522	0	9217	25	304	0	0	0	2	0
23	Diner's	27074	0	2783	37	72	11	0	0	3	0
24	Giordano	20267	0	46318	0	35	12	0	0	0	0
25	Logo	6618	0	6825	107	0	0	90	239	0	0
26	Any Baby	7859	0	706	18	5	0	0	0	1	0
27	Baby Shop	24713	9	2437	24	64	0	0	0	3	0
28	Broast and biryani	3238	0	136769	88	224	16	0	0	0	0
29	Nishan linen	0	0	13671	34	92	0	0	0	2	0

S/No	Sample Name	Names of Additives (ppm)									
		Ti	Cu	Ca	Fe	Zn	Hg	Cr	Pb	As	Cd
30	Saeed Ghani	41741	19	21233	0	152	0	0	0	3	0
31	Rahat	4694	0	154485	113	80	0	7668	480	0	0
32	Limelight	9388	0	25247	30	75	0	0	0	3	0
33	outfitters	13207	0	66675	79	40	15	0	0	0	7
34	Breakout	459	0	13775	25	58	13	1453	6967	0	0
35	Leena	14696	0	88750	72	27	12	0	0	0	0
36	Jamil Sweets	988	0	26055	223	59	0	435	2251	0	0
37	Ethnic	10904	0	30525	55	31	0	0	0	0	0
38	Generation's Store	0	138	918690	67	192	0	424	2041	0	0
39	ARQ's	18604	0	1751	0	21	11	0	0	0	0
40	Mango	12286	0	11526	501	389	0	0	0	2	0
41	J.	21962	10	532	215	61	0	0	0	3	0
42	Metro Cash & Carry	0	0	106429	72	39	12	0	0	0	0
43	NIKE	41	0	71	14	102	0	75	645	0	0
44	Gourmet	8571	0	102367	99	295	0	0	0	0	0
45	Subway	13	10	11	17	66	0	0	0	2	0
46	Domino's	11218	171	105535	0	66	0	0	0	0	0
47	Levi's	41	14	59	0	131	0	0	0	2	0
48	Haleem Ghar	8047	0	131003	80	687	0	1	0	0	0
49	K&N's	15197	0	7879	0	242	0	0	0	2	0
50	LEGENDS	0	0	59987	54	253	11	0	0	0	0
	Highest Value	41741	419	918690	501	1728	27	7668	6967	5	31
	Lowest Value	0	0	11	0	0	0	0	0	0	0

Table 3: Non-degradable plastic bags

S/No	Sample Name	Names of Additives (ppm)									
		Cu	Ti	Ca	Fe	Zn	Hg	Cr	Pb	As	Cd
1	Cambridge	20085	8	50	0	65	0	0	0	3	0
2	Borjan	16991	0	121128	103	43	0	0	0	0	0
3	Cougar	18552	0	22329	35	45	0	0	0	0	0
4	The Hart Pharmacy	7282	0	130753	0	559	14	0	0	0	0
5	Illusions	8312	0	7526	21	57	0	0	0	2	0
6	Hopscotch	995	0	112310	107	60	0	0	0	0	0
7	Hush Puppies	13669	0	2025	17	59	0	0	0	2	0
8	minnie minors	21303	0	70	20	26	0	0	0	0	0
9	Sonali	19760	0	52546	47	192	0	0	0	0	0
10	Eden robe	11342	0	1084	18	45	0	0	0	3	0
1	Al-Latif Chemist	9701	0	126797	108	23	0	0	0	0	0
12	Shifa Medical	16930	0	121166	103	43	0	0	0	0	0
13	pink local	0	0	88322	94	482	0	0	0	0	0

S/No	Sample Name	Names of Additives (ppm)									
		Cu	Ti	Ca	Fe	Zn	Hg	Cr	Pb	As	Cd
14	red local	5032	0	29879	275	266	0	24	116	0	0
15	Grey local	13743	91	8244	83	116	0	40	150	0	0
16	Blue Local	3311	85	126899	155	609	0	0	0	0	0
17	green local	0	0	100016	104	0	16	0	0	0	0
18	yellow local	0	0	88119	110	481	15	0	0	4	0
19	Transparent Local	0	0	224	0	70	0	0	0	2	0
20	Black Local (rare)	3644	48	37092	919	407	0	1	106	0	0
21	Pepper land	26272	171	24	32	111	0	0	0	3	0
22	Vision optic	26256	0	302	0	39	0	0	0	4	0
23	Sargent Major	13085	86	25528	55	50	11	0	0	3	0
24	Threads & threads	0	15	2340	5127	60	0	0	0	3	0
25	food 24 hours	8061	0	109655	65	254	13	0	0	5	26
26	Amna fabrics	0	1786	17890	89	766	0	0	0	0	0
27	(Thank you) blue	0	1245	3314	26	230	0	12	0	3	0
28	(Thank you) yellow	32	0	778	0	75	33	1720	8003	0	0
29	(Thank you) white	8233	15	77285	62	173	0	0	0	0	0
30	Broz	28803	0	3006	43	201	3	0	0	0	0
31	Sputrnick	1550	43	3608	0	55	25	1073	5484	0	0
32	Datchi	8776	558	37411	30	389	0	0	0	0	0
33	Kashmir arts	20971	0	116099	0	324	0	1	0	0	0
34	Kids master	15133	0	33	20	49	0	0	0	2	0
35	Nizam Watch	11879	0	83715	62	321	0	1	0	0	0
36	I.n.c	16335	8	5615	26	41	0	0	0	3	0
37	Gul Ahmed	16191	51	46802	149	234	11	0	0	0	0
38	Al Jannat	13247	0	49412	74	96	14	0	0	4	0
39	Sattar Buksh	11134	5	1340	25	225	0	0	0	2	0
40	Stonage	16970	0	112544	0	69	14	0	0	0	0
41	Generations	0	98	42	11	81	0	0	0	2	0
42	Outfitters	27808	0	5500	35	63	0	0	0	0	79
43	Phulkari	9499	0	70085	88	203	13	0	0	0	0
44	Bakeman	322	0	144847	0	41	0	98	694	0	0
45	Explore	0	7	70	16	110	0	0	0	0	0
46	Kaish Cosmetics	6593	0	133463	119	252	19	0	0	0	0
47	Wazir Tailors	23636	0	1040	21	82	10	0	0	0	0
48	The merino tailor	13348	0	122992	79	369	19	0	0	0	0
49	Diner's	128	576	4539	14	363	0	0	0	2	0
50	Albedo	15319	0	0	0	40	0	0	0	5	0
	Upper limit	28803	1786	144847	5127	766	33	1720	8003	5	79
	Lower limit	0	0	0	0	0	0	0	0	0	0

The following are the reasons for the behaviors and the patterns shown by Titanium and Copper observed by the analysis of the samples of both degradable and non-degradable plastic bags.

Titanium (Ti)

Titanium was the abundant metal that was found to be present in Degradable plastic bags only; it was present in traces in non-degradable plastic bags. The highest value of titanium that is observed by analyzing Degradable Plastic bags samples was 41741 ppm while the least value observed was 0 ppm, similarly the highest value received by analyzing non degradable plastic bags was 1786 ppm and the least value was 0ppm the reason of its presence in Non-degradable plastic bags in abundance, because of the use of Titanium Dioxide powder in the manufacturing of degradable plastic bags which is Photolytic. The discussion that taken into consideration for the titanium dioxide is photocatalytic mechanism. Water and oxygen close to the surface of the finely divided titanium dioxide particles are converted by an electron and a hole created inside the particles into hydroxyl radicals or hydrogen peroxide. Because of the strong oxidation-reduction function performed by these radicals, harmful substances, like carbon dioxide gas, are transformed into less harmful substances, such as hydroxyl radicals, and clarity is achieved. If finely divided titanium dioxide particles, light, water, and oxygen are present, the photocatalytic action of the particles is believed to be continuous. As application various attempts of incorporating Titanium Dioxide in medium have been made, The Titanium Dioxide powder is suitably shaped for handling articles such as fiber and plastic bags. However, the strong photocatalytic action of titania leads to the destruction of the medium itself, including paper, plastic, and textile fibers, as well as hazardous organic compounds and environmental contaminants. The practical application of photocatalyst titanium dioxide is hampered by this. Due to its excellent handling qualities, a coating material made by combining finely divided titanium dioxide particles with a binder is gaining interest. Natural resins, thermoplastic polymers, and thermoplastic polymers are a few examples of organic polymers that can be used. Because a coating of a largely water-insoluble organic substance forms this prevents the organic polymer from coming into direct contact with the photocatalytic activated surface of the titania, the organic polymer acts as medium for the deterioration and decomposition [12].

Copper (Cu)

The range of copper for both Non degradable and degradable plastic bags was (0-28803) ppm and (0-419) ppm respectively, in non-degradable copper was observed to be present in very large amount as a major content.

Copper phosphate salts, such as copper sulfate, copper phosphate, copper thiocyanate and cupric hydroxide phosphate, are present in thermoplastic composites. The ideal amount of copper phosphate salt to add is between 0.1 and 5 parts by weight, and the ideal copper phosphate salt particle size is less than10 μm [13].

Copper that enters the atmosphere, bonds to minerals. Because of this, it rarely reaches groundwater and does not travel very far after release. Copper can move quite far in surface water, either as free ions or suspended on sludge particles. Since it doesn't decompose in the environment, it can build up in plants and animals. Only a small number of plants can survive in soils high in copper. For this reason, the plant diversity is low in the vicinity of factories that dispose of copper. Since copper poses

a severe risk to cropland productivity, according to plants. Depending on the soil's acidity and the amount of organic matter present, copper can have a significant impact on how some farms operate. Manure containing copper is nevertheless applied despite this. Because copper has a detrimental effect on microorganisms and other earthworms, the breakdown of organic matter may be considerably slowed down. When agricultural soil becomes polluted with the presence of copper, animals will come into contact with levels that are harmful to their health. Since copper's effects are most noticeable at low quantities, sheep are the animals that suffer the most from copper poisoning [14].

Co-existence of Chromium (Cr) and Lead (Pb)

It has been observed that either both Chromium and Lead were present together in the same samples or they both were absent. The reason for this behavior of these two metals was because both chromium and Lead were used together in the printing ink for designing logos and monograms. The highest values of Chromium and Lead observed in degradable plastic bags were 7668 ppm and 6967 ppm respectively and the least values are 0 ppm for both. The highest values of Chromium and Lead observed in non-degradable plastic bags were 1720 ppm and 8003 ppm respectively while the lowest values of both are again 9 ppm.

Various amounts of heavy metals, such as chromium and lead impose serious health effects even with only small amounts. They can contaminate the food and travel through water supplies and reach the atmosphere. This, in the past, has badly affected the Central Nervous System of Young children. Infants and young children should have to be kept safe, not be exposed unnecessarily to materials containing significant amounts of such heavy metals, and it is highly recommended that these should be replaced by non-hazardous substances in toys (Plastics) and printed papers (comics), as we see infants tend to chew and sometimes swallow such materials. Some people also say that these heavy metal compounds, normally used as pigments, are not necessarily dangerous, because the pigment particles may be insoluble or well protected by suitable coatings-as for instance in many plastic toys that use cadmium-based or lead-based pigments. Hence there is need for an extraction test simulating the conditions of the human stomach rather than an analysis for the total lead [15].

Chromium (Cr)

It is well known that chromium, particularly hexavalent chromium, has a significant impact on the environment. Numerous sectors, including metallurgy, electroplating, paint and pigment manufacturing, tanning, and wood preservation, use chromium extensively [16], Production of pulp and paper, as well as of chemicals. Wastes from these businesses (such as slag, fly ash, sludge, etc.) are frequently utilized as backfill at sites after demolition, for tank dikes, and as fill material in several locations for re-establishing marshlands [17]. Cr (VI) seeping and leaching from soils into groundwater at many of these locations is a serious health risk. Water supplies are particularly heavily contaminated with Cr especially from various tanning industries.

When it comes to nutrition, Cr (III) is necessary for both humans and animals to eat a balanced diet to prevent negative effects on the metabolism of fats and carbohydrates. Humans are likewise harmful to Cr (VI) at large concentrations. When consumed in excessive quantities, hexavalent chromium (Cr VI), a strong and exceedingly toxic carcinogen, could be fatal to both humans and animals. It

primarily enters humans through the air through inhalation. [18]. This chromium is in fact a part of plastic bags which leaches out slowly and causes harmful effects on animals and human beings.

Lead (Pb)

Lead is a hazardous metal, and it causes seriously harmful impact on public health and causes extensive environmental damage. It may have seriously detrimental consequences on children's health. Lead damages the brain and central nervous system at high exposure levels, resulting in unconsciousness, convulsions, and even death. Even after surviving severe lead poisoning, children may develop behavioral problems and intellectual impairment. The low levels of exposure cause no obvious symptoms which was used to be considered safe, but now it is known to produce a spectrum of injury across multiple body systems. Lead can affect children's brain development resulting in reduced intelligence quotient (IQ), behavioral changes such as reduced attention span and increased antisocial behavior and reduced educational attainment. Lead exposure also causes anemia, hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs. The neurological and behavioral effects of lead are believed to be irreversible [19].

Presence of Calcium (Ca) in abundance in both kinds of samples

In the XRF analysis of plastic bags a large quantity of Calcium has been detected in results, the highest value of calcium in the list of degradable plastic bags is s 918690 ppm and the lowest value was 11 ppm, while in the list of non-degradable plastic bags the highest value of calcium is 144847 ppm whereas the lowest value was 0 ppm. The reason for the existence of this metal in large quantities is because of the calcium carbonate $CaCO_3$ used in plastic bags. It has been proven that inorganic fillers can increase mechanical performance. Many fiber reinforcements like glass fibers and inorganic fillers like clay, calcium, talc and calcium carbonate are normally indulged with thermoplastic polymer. These composites have strength, heat resistant temperature, and superior stiffness with unreinforced polymers. Perhaps these materials are not biodegradable. In different reinforcing materials, only $CaCO_3$ is cheap material and has hydrophobic nature. It is proven that penetration of $CaCO_3$ with any other material can improve biodegradation process of polymers which have ester bond. This could be the reason why the highest value of calcium in degradable plastic bags is nine times more as compared to the value of calcium in non-degradable plastic bags [20].

Small amount of trace elements i.e., Arsenic (As), Mercury (Hg), Iron (Fe), Zinc (Zn) and Cadmium (Cd)

A very small amount of Arsenic (As), Mercury (Hg), Iron (Fe), Zinc (Zn) and Cadmium (Cd) was also found which was disquieting because these metals are toxic and the plastic bags containing these metals are used for carrying eatables like bread, bakery products, vegetables, and fruits as well, it can be then entered into the food chain.

Arsenic (As)

Arsenic exists in solid, dissolved, and gaseous form. As both inorganic and organometallic species, arsenic can be converted into arsenic acids (3+ and 5+) and to methylated arsines (3-) under an aerobic condition by bacteria and other microorganisms' Different arsenic species indicate varying degrees of sensitivity in both terrestrial biota and aquatic. Both biotic and biotic variables alter their sensitivity. Inorganic arsenates are more potentially dangerous than arsenates, and

inorganic arsenicals are more toxic than organo-arsenicals. There are differences in the toxicity and the absorption mechanisms of arsenate by various species. This is why various species respond differently to arsenate and arsenite.

Compounds of arsenic cause acute and chronic effects in individuals, populations and communities at varying concentrations ranging from a few micrograms to milligrams per liter, depending on species, time of exposure and endpoints measured [21]. These effects include immortality, inhibition of growth, effect on photosynthesis and reproduction, and effects on behaviors. Arsenic-contaminated environments are characterized by limited species abundance and diversity. If levels of arsenate are high enough, only species which exhibit resistance may be present. The plastic bags through garbage trucks, wind and water runoff reach to the water bodies and causes the release of arsenic in the medium where they currently reach.

Mercury (Hg)

Mercury is a hazardous element, and its toxicological and ecological effects fully depend upon which chemical species is present. Species transformation and distribution process in every aquatic system are governed by different chemical, biological and physical factors. By depending on conditions of environment inorganic mercury usually converts into more toxic form called as methylmercury and can accumulate into aquatic biota. [22].

This mercury is released from the plastic bags when they slowly degrade and become a part of soil and water [23]. The range of mercury in both degradable and non-degradable plastic bag samples was about (0-27) ppm and (0-33) ppm.

Iron (Fe)

The range of iron found in both biodegradable and non-degradable plastic bags was (0-501) ppm and (0-5127) ppm respectively. Gall inks represent printing inks made with iron. It is utilized as ferrous sulphate, which is combined with gallic acid to produce black printing ink [24]. It therefore stands to reason that the printing inks would be the cause of the iron metal identified in the samples.

Zinc (Zn)

A metal known as zinc is incorporated into certain plastics to provide them strength. It is included as powdered zinc. The highest value of Zinc obtained from the analysis in both degradable and non-degradable plastic bags was 1728 ppm and 776 ppm respectively, while the least values in both kinds of samples were 0 ppm [25]. The concentration of Zinc powder by volume ranges from 0 to 20%. In general, composites exhibit worse mechanical qualities than unfilled polymers. Compared to unfilled polymers, plastics have a higher density and hardness. When compared to an unfilled polymer, the thermal stability of polyethylene charged with zinc powder is superior. Zinc powder is added to polyethylene to improve its thermal diffusivity and conductivity while reducing the specific heat. [26].

Cadmium (Cd)

Cd refers to toxic metal that exists naturally and as a pollutant releasing from agricultural and industrial sources. The main source of cadmium intake in the non-smoking population is food. Cadmium can stay in the walls of kidney (10–30 years) and the concentration is same as that in urine. Cd is nephrotoxic in nature, causing extreme kidney tubular damage. It also causes bone damage, either via a direct effect on bone tissue or indirectly because of renal dysfunction followed by

glomerular damage with decreased glomerular filtration rate, and eventually to renal failure [27]. Recent research has shown that is also carcinogenic. Roughly non-smoking adults have 0.5 µg/g of urinary Cd or slightly higher in non-exposed areas. For smokers this proportion is considerably higher. For that reason, steps should be taken to reduce exposure to a minimum, and the tolerable limits of daily intake could be set to keep ourselves safe [28]. The range of Cadmium in both degradable and non-degradable plastic bags is quite low, in all hundred samples only four samples were found to be cadmium positive.

Metals which were analyzed but are not detected due to absence.

The instrument (XRF) also scanned for other heavy metals including Mn, Au, Ni, Co, Ag, Pt, Br, Ta, V and Br but the results were 0 ppm in all samples only one non degradable plastic bag of Black color contained Bromine (Br), and the value was 282 ppm.

Conclusion

Biodegradable plastic bags contain enormous amounts of Titanium which makes them degradable while non degradable plastic bags contain an enormous amount of copper that may be makes them non degradable.

The ink used to print various plastic bags is the root cause of lead and chromium presence.

Trace amounts of several other heavy metals were also found mainly Arsenic (As), Mercury (Hg) and Cadmium (Cd), Chromium (Cr). This might be because of some additional printing material used for designing and writing.

The Degradable plastic bags could be more harmful than non-degradable plastic bags because the non-degradable plastic bags cause immobilization of the heavy metals used for their formation and printing while the degradable plastic bags degrade by photolysis due to the presence of Titanium dioxide releasing other heavy metals into the environment.

Authors' contributions

Conceptualization, S.A.; Methodology, S.A. and S.H.Z.; Formal analysis, S.A.; Writing original draft preparation, S.H.Z, S.M.Z.; Editing, review and writing, S.H.Z., and S.M.Z.; Supervision, S.A.K. All authors have read and agreed to the published version of the manuscript.

Funding

Authors receive no external funding.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Acknowledgements

The authors are thankful to Bahria University Department of Earth & Environmental Sciences and to the laboratory of Environmental Protection Agency Islamabad for their support for this Research.

Conflicts of interest

The authors declare no conflict of interest.

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