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Poultry feed contamination and its potential hazards on human health

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Abstract

The poultry farm industry is growing quickly and tremendously contributing to meeting the increasing protein demand of the rapidly growing population through eggs and meat supplementation. It is a good and cheap source of low cholesterol and high protein meat and provides essential amino acids, vitamins and minerals. The poultry industry is big and developing worldwide. Because of the tremendous commercialization of poultry farms and the increased number of birds in poultry farms, there was a need to prepare poultry feed on an industrial scale. Because of industrialization and increasing environmental pollution, there are much higher chances that poultry feed may get contaminated with some toxic compounds during the process of preparation. Hazards associated with animal feed can be chemical, biological, or physical. Contamination of poultry feed may occur during handling, storage and transportation, or it may result from accidental or deliberate. Risk management should be based upon prevention rather than reaction after detection of the problem. Food safety hazards should be taken seriously to control side adverse effects in animals and humans. So, governments should take strict measures to avoid any toxic contamination hazardous to human health.

Introduction

The demand for low-cholesterol meat having high protein source has led to an excessive expansion in the poultry industry worldwide [1] . In 1900, chickens did not have the current size, nor did they have access to modern rations, clean water and a hygienic environment. At that time, it was not an important source of food for humans. They were raised in houses on a smaller scale, not on a larger scale on farms. Chicken was only used as food on special occasions and eggs were considered luxury foods, but in 1923 Mrs. Wilmer Steele, from Delaware, started farming and flourished in a farmhouse with a capacity for 500 chicks that could be used like broiler birds. In 1926, she founded an aviary with 10,000 birds. It is considered the pioneer of the commercial broiler industry. This was the beginning of limited chicken farms. This chicken mortality rate has dropped to 5 percent [2]. In the 1970s, the modern era of the chicken industry began with advances in nutrition, the selection of genetically modified birds and the use of antibiotics and other substances in the feed. This large-scale production not only revolutionized the chicken industry, but also created threats to human health through the consumption of its meat. These human health problems are due to the feed provided to broilers. Chicken feed mainly consists of grain seeds, soybeans, grass, biscuits, meat, blood, fish meal, fat, oil, decorticated cottonseed bran, corn gluten bran, guar bran, peanut cake minerals and sub therapeutic antibiotics, etc. This food may be contaminated with soil toxins, fungi and parasites. This contamination can affect the health of chickens and, ultimately, humans[3], [4].

Nutritional significance of broiler meat

Chicken meat, a type of white meat, is different from other meat (red meat) of cows and goats, etc. It is an excellent source of high-quality, high-protein vitamins and minerals. Chicken is used as a cheap source of protein by millions of people. Due to its low-fat content, it is preferred by nutritionists and health professionals over red meat. Chicken has less than 3g of fat / 100g compared to red meat with 5 to 7g / 100g. The presence of a higher percentage of monounsaturated fats and a smaller amount of healthy saturated fats makes your meat valuable. Using skinless meat can protect people from developing coronary artery disease and hypertension. It is the source of essential polyunsaturated fatty acids, such as omega (n) 3 fatty acids. It provides essential amino acids such as lysine, sulfur-containing amino acids (methionine and cysteine), threonine and tryptophan, which are not found in cereals [5].

Poultry feed myth vs. reality

Misconceptions about chicken meat and their feed are a hot topic that leads to several myths. A myth and news circulating on social networks that steroids and hormones used in chicken feed cause hormonal changes in humans and various diseases such as polycystic ovary syndrome (PCOS) and early menarche etc [6]. And there is also the misconception that hormones / steroids are used to make chickens grow faster and bigger. But it prohibits the use of hormones in chicken feed [7]. The increase in broiler growth is due to the breeding selected through artificial insemination. It is through this chicken that genes are selected to obtain more muscle and the qualities necessary for better production. An increase in chicken growth is also due to improved feed and the availability of a hygienic environment. Therefore, no hormones are used to support large numbers of birds. The method for obtaining growth hormone to increase muscle mass is to give chickens an injection of the hormone every day. Daily injection of hormones is not possible in large-scale poultry production due to the greater number of chickens in the herd. Second, hormone feeding is not as cheap as the commercial benefits and expensive enough [8].

Poultry feed and safety

With advancement of commercial production of poultry and poultry feed on larger scale, the safety of poultry feed and its possible hazard on human health is matter of great concern. Pollution and advancement in technology is causing immense problems globally, causing risks not only to human beings but also to animals. Followings may be potential risks to human health through chicken feed (**Fig. 1**).

1. Use of toxic plants and pesticides on crops [9].
2. Use of therapeutic and sub therapeutic antibiotics in poultry feed [10].
3. Use of genetically modified crops, enzymes and organism in commercial feed production.
4. Contamination of feed with toxic substances like dioxins, melamine and dibenzofurans. [11].
5. Contamination with radionuclide.
6. Use of byproducts of biofuels in animal feed.
7. Use of nanotechnology byproducts in feed.

8. Contamination of feed with heavy metals like Lead, Mercury, Arsenic, antimony and many others through water, crops and industrial waste.
9. Poultry feed as a target for bioterrorism.
10. Contamination of feed with microbes and mycotoxins and presence of endoparasites.

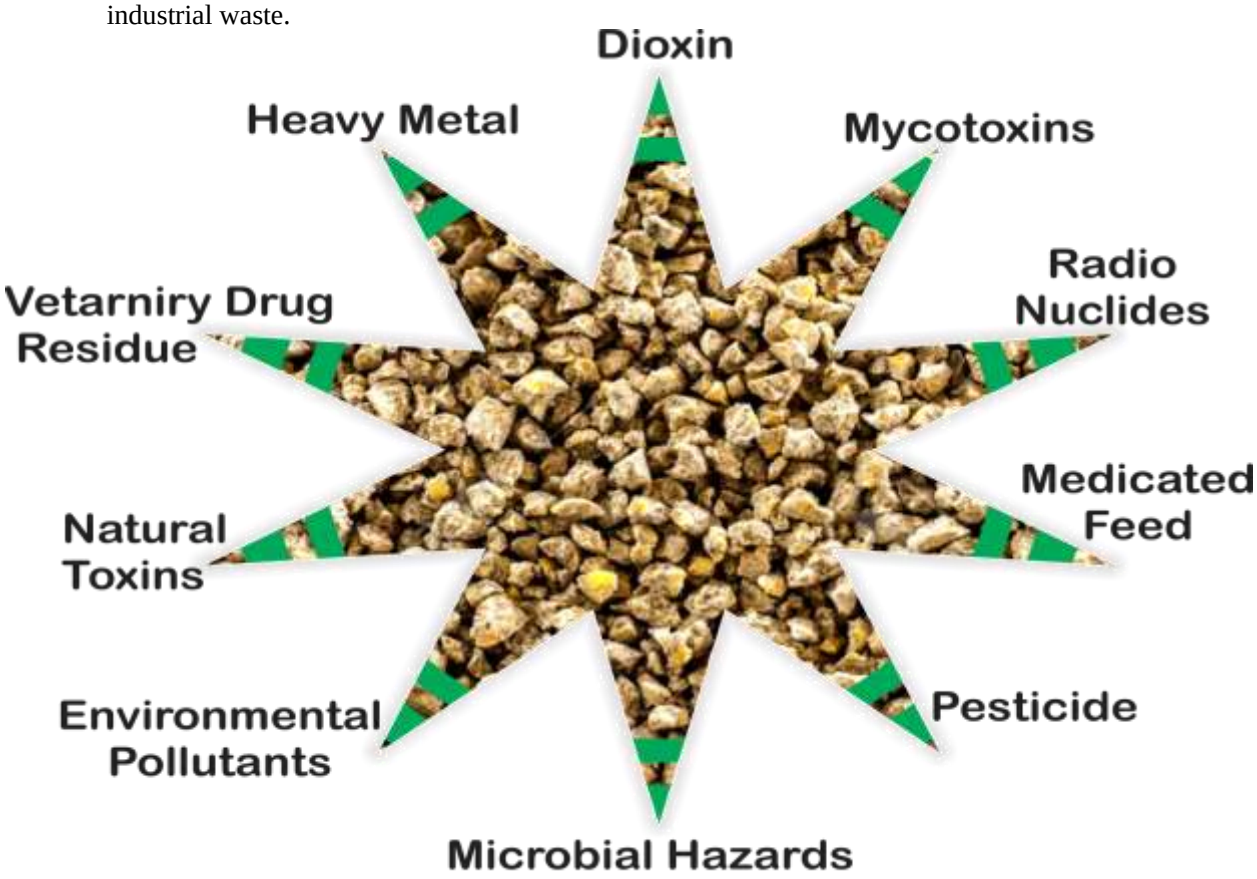

Fig. 1: Sources of Contaminations in Poultry Feed

Effect of pesticides on human health through poultry feed

Pesticides are used to control pests and weeds in the United States. If the plants are not harvested after the correct time interval for spraying pesticides, their residues may remain on the plants. (Environmental Protection Agency) Pesticide residues can remain in food after being applied to food crops (IUPAC, 1997). Therefore, poultry feed sometimes contains pesticide residues. Several studies have shown that these pesticides are deposited in chicken meat and on farm eggs. And, when using these contaminated pesticides for meat and egg, they have toxic effects on human health. A study was carried out in Jordan in which 519 samples of poultry eggs, chicken meat and beef and lamb meat were examined for the presence of organochlorine pesticide residues (OCP). The results showed that 28% (38/134), 20% (23/115) and 49% (131/270) of the examined egg, chicken and meat samples had OCP residues [12]. In another study conducted in China, several samples of animal feed and chicken organs were analyzed on a farm in Beijing to estimate the residues of hexachlorocyclohexane isomers (HCHs) and dichlorodiphenyltrichloroethane and metabolites (DDTs). The average fresh weight concentrations of toxic pesticides HCHs and DDTs were 0.122 ± 0.061 ng / g and 0.051 ± 0.038 ng / g in poultry meat. The accumulated amount of pesticides HCHs and DDTs also increased as the chick grew [13]. Poultry meat with pesticide residues can have several adverse effects on human health. It can affect the nervous and reproductive systems and cause cancer [14] . Different studies also show association between organophosphate insecticide exposures and neurobehavioral problems [15] , [16] , [17] . Pesticide exposure may cause neurological, birth defects, and fetal death [18].

Effects of antibiotics on human health in poultry feed

It is common worldwide to keep chickens, turkeys and laying hens in large flocks of 10,000 to 20,000 birds. It was important to have disease control programs for such a high concentration of bird chicks in a confined space. Antibiotics have played an important role in maintaining the health of poultry chicks since 1950. Approximately 45% of antibiotics produced in the United States each year are administered to animals [19].

In the past 30 years, antibacterial drugs have been used extensively in poultry feed in sub therapeutic doses. Sub therapeutic use of antibiotics improved not only feed conversion, but also the growth rate of chicks. It significantly reduced the morbidity and mortality of chicks from various diseases. The administration of antibiotics in drinking water is also becoming increasingly important in poultry production.

It is not well established that the effects of sub therapeutic antibiotic use are due to: (a) increased animal metabolism, (b) increased absorption and use of nutrients, (c) antimicrobial activity, or (d) a combination of all previous.

It is difficult to determine the role of the use of antibiotics in animal feed at subtherapeutic doses in the development of resistant bacterial populations compared to the therapeutic use of antibiotics. Salmonella is a common cause of food poisoning in humans. Studies have shown that animal foods are usually involved in the cause of the infection. Salmonellosis has been observed in humans from antibiotic resistant strains of cattle [20] . This resistance to antibiotics was the result of the widespread use of antibiotics, but there is no evidence of a connection with the sub therapeutic use of antibiotics in animal feed. It is difficult to rule out whether this food was contaminated before slaughter or if the grocer was the vector of the disease.

However, there is no well-established evidence that the sub therapeutic use of antibiotics results in drug resistance in humans. These studies are very complex and time-consuming. However, studies can be developed to determine drug-resistant diseases in poultry workers who have close contact with animals or products of animal origin, as well as people working in industries that have no contact with animals or products of animal origin. Some information could be obtained through surveys of the available information, which show that the dangers posed for human health from the sub therapeutic use of antimicrobials in animal feed have not been established or refuted. The lack of data linking human diseases to this sub therapeutic application should not be equated with evidence that the proposed risks do not exist. The studies necessary to identify and measure a specific risk have not been performed [21], [22].

The use of sub therapeutic antibiotics in poultry feeds caused serious concerns regarding effects of its use on human health. The Food and Drug Administration (FDA) has proposed a ban on some antibiotics at sub therapeutic levels in feed because of the potential for compromising the health of humans.

In advanced countries therapeutic antibiotic use only occurs after other management strategies have been failed. The birds are inspected by vets before and after antibiotic administration. And withholding period is given prior to processing those chickens administered with antibiotics [23]. Only drugs approved by National Health and Medical Research Council and the National Registration Authority are used [24].

Effects of dioxins and dioxin-like substances through poultry feed

As dioxin and Dioxin like compounds are abundantly present in environment due to pollution, there is threat of contamination of animal feed with this toxic compound. After the Belgian dioxin crisis in 1999, scientists are considering Dioxin as important toxic contaminant of animal feed. Dioxin may contaminate product (e.g., clay minerals), or can become part of product during processing e.g., lime in citrus pulp. Poultry Feed can be contaminated with Dioxin, if fuels are utilized for drying of feed e.g., treated wood, contaminated fuel oil and poor-quality coal can be source of this dioxin. Dioxins can also contaminate crops grown in the nearby area of some industrial processes like incinerators. Dioxin gets deposited on plants, soils, and in water from the atmosphere or through fertilizers, pesticides, and irrigation [25]. Poultry animals are fed mainly on grains obtained from cereals. In poultry feed, fats and meat products obtained from different animals, fish products, grains and other supplements are added to get best-performance and production goals. Dioxin, and DLCs may be present in animal tissues that are used in feed. Dioxin and dioxin-like compounds (DLCs) and Dibenzofurans after contaminating the animal feed enter into human food chain. Contamination of commercial poultry feed e.g., DLCs in poultry in the

United States [25], [26], has resulted high level of DLCs exposure to the poultry animals [11].
One study revealed that poultry animals having access to soil ingest DLCs during feeding if surrounding enjoinment is having DLCs [27]. One study also showed that egg producing hens fed to soils produce eggs contaminated with DLCs [28].
This toxic compound cause number of health hazards to human beings. Its exposure may cause diabetes, cancer, cardiovascular problems, hormonal imbalances like reduction in thyroid and testosterone hormones, immune system disorder, porphyrias, skin and nail abnormalities. In females it may cause early menopause, delayed breast development and endometriosis. It may be associated with altered expression of metabolic enzymes and growth factors [29], [30] If human beings are exposed during developmental phase to this toxin, it may cause altered neurobehavioral like hearing and psychomotor problems, gender related behaviors, cognition and dentition problems. One study has revealed that neonates born to mothers with elevated plasma dioxin due to exposure to this toxin 30 years before in past, were having raised thyroid-stimulating hormone [31].

Heavy metal toxicity in poultry feed and effects on human health

The excess of elements in minerals causes adverse effects in animals and in the human population that consumes animal meat. These essential minerals must be present in the feed of the birds in ideal concentrations for the safety of the health of the animal and human populations. These minerals must be included in the feed according to the guidelines of nutritionists. However, there is still the possibility of contamination of poultry feed with toxic elements from the environment or with food additives, which must be monitored closely. Various ingredients in poultry feed, such as minerals, additives for marine feed (such as fish meal, algae), trace elements (copper sulphate, zinc oxide), Roxarson (kills parasites and improves meat color) and anti-caking agents may be the source of heavy metal contamination. Factors such as groundwater contamination, environmental pollution and industrial waste are the causes of food contamination in the United States. Mercury, cadmium, lead and arsenic are of serious concern because they have toxic properties and do not have an important biological function [32] ,[33]. Arsenic, Lead, Mercury and Zinc cause serious health problems [34].European Regulation (EC) No 882/2004 make rules to check the compliance with feed laws, and animal welfare rules [35].

Arsenic

Arsenic usually found in the environment both in organic and inorganic forms. Various Arsenic compound like Phenyl arsenic acids (organic) are used as poultry feed additive for coccidiosis [36]. The Food and Drug Administration has approved many additives for poultry. Such as Roxarson organic arsenic (3-nitro-4-hydroxyphenylsonic acid, trade name 3-Nitro) and arsanilic acid (2-aminobenzenesonic acid or C6H8 AsNO3) for use in poultry feed. Roxarson is a common arsenic-based additive used in chicken feed. It promotes growth, kills parasites and increases the pink pigmentation of chicken meat. Roxarsone is considered benign in its original form. However, in chickens, it can be converted to more toxic inorganic arsenic under anaerobic conditions [37]. A withdrawal period is required prior to process animals for human use to reduce tissue levels of arsenic. Studies show that arsenical use is much prevalent in feed production [38]. The Institute for Agriculture and Trade Policy (IATP), a U.S. has, estimated that use of arsenical drugs exceeds 2 million lb per year [39].The presence of arsenic compounds in animal wastes is directly related to the presence of arsenicals to animal feeds. It was reported that Arsenicals excreted by animals in waste is proportional to the concentrations administered in feed [40] . Samples of poultry litter from aviaries in Virginia were analyzed. In the poultry litter, an average of 40.4 mg / kg of total arsenic (n = 41) was present. The bed contained arsenic in the range of 1.1-59.7 mg / kg. Poultry farm workers are also at risk of exposure to roxarson and arsenic in waste, dust and the environment. One study showed that, compared to arsenite, Roxarson increased angiogenic potential and decreased cytotoxicity in cultured human epithelial cells [41]. This study suggested roxarsone-induced vascular changes may cause tumors and vascular disease. Use of roxarsone in poultry feed has become controversial. Many food suppliers have stopped using roxarsone. But still, about 70 percent of broiler chickens are fed on feed having roxarsone in the U.S. The chronic exposure to Arsenic can cause different skin, lungs, liver and blood manifestations. First of all Prof. K. C. Saha in July 1982 at School of Tropical Medicine, Calcutta diagnosed patient with Arsenic poisoning in 1984 [42]. The skin changes may manifest as presence of erythematous flush leading to melanosis,

hyperkeratosis, and desquamation. There are patchy dermal pigmentations like rain drops on dust road [43]. Chronic exposure may cause basal cell and squamous cell Carcinomas. (Pershagen, G. Braman) a rare precancerous skin lesion known as Bowen's disease is considered to be caused by arsenic and human papilloma virus (HPV) [44].

There may be anemia, Thrombocytopenia, megaloblastic anemia and leucopenia and its toxicity can cause decrease in hemoglobin, packed cell volume, erythrocyte count, and total leukocyte count, and lymphocytes [45]. Lung complications like Asthmatic bronchitis may occur. Problems like hepatomegaly, splenomegaly& ascites may be seen in many cases. Chronic Arsenic poisoning may cause cancer of skin, lungs, bladder and uterus [46].

Lead

Soil, air and water, can be contaminated from smelters, combustion engines, brning oil, industrial waste, lead pipes, etc. [47] . Industrial waste, Lead can contaminate soil and water. And the plants that are used for poultry feed can settle in the soil. Lead can also contaminate water if lead tubes are used. Lead comes in two forms: one is organic and the other is inorganic. The organic form of lead is more toxic than the inorganic form. One study found that the concentration of lead residues in the liver, kidneys, eggs, ovaries and fallopian tubes of laying hens increased with increasing lead concentration in the feed. The dose-response relationship was therefore significant [48]. There is seen positive correlation between lead concentration of egg with dietary lead level and it was seen that concentration of Pb in eggs was more in yolk and lowest in ALB [49] , [9]. After absorption from gastrointestinal tract there is formation of metallo-proteins containing Lead, which are then transferred to different parts of chicken. Lead is deposited in bones, kidneys, liver and different tissues of bird [50],(NRC 2001, EFSA 2010). Lead affects almost every system of animal body like renal, endocrine, cardiovascular, immune system, reproductive and musculoskeletal system [51], MVM 2008). Lead contamination is also seen in egg yolks and different tissues of chicken like skeletal muscles [9]. These contaminated eggs and meat cause potential public health hazard which should be monitored strictly. In humans lead exposure causes toxic effects both in children and adults. Lead is easily distributed in the body, and can cross the blood-brain barrier [52]. Ninety percent of lead is deposited in the active matrix of bone which act as inert reservoir of Pb in the body [53]. In children it may cause neurobehavioral disorder, poor cognitive performance, delayed puberty, and growth retardation. Toxicity in mother can cause reduced fetal growth. In adults It may cause decrease in kidney function, hypertension, degenerative disorders of CNS, tremors and increased tendency to develop cataract [54].

Mercury

Soils can retain mercury for a long duration of time, and mercury deposited in soil may continue to be released to surface waters for longer period of time may be for thousands of years. Poultry feed may get contaminated with mercury during processing or from Feed ingredients, like use of mercury contaminated fish and crops etc. Mercury from the atmosphere may also get deposited on plants [55]. Plants not only get contaminated with mercury from air but also from uptake of gaseous Hg0 and when these mercury contaminated plants are used to make poultry feed causes serious adverse effect not only to chicken but also to human. In one study it was evident that when seed grain treated with organo-mercurial fungicides was used to feed poultry the residue of mercury was found in eggs and meat of chicken in significant amount [56].

Mercury poisoning in humans can cause several health problems, such as: B. Effects on the central nervous system, e. Limb numbness. Tremors, ataxia, dysarthria and narrowing of the visual field. Damage to the cerebellum and facial cortex. It can also cause nausea, vomiting and abdominal pain, diarrhea and exposure-related colitis. Other symptoms include discoloration of the gums, perioral paresthesia and drooling.

The minimate tragedy is known for its organic mercury poisoning, which caused teratogenic effects similar to cerebral palsy [57]. It may cause mental retardation, , seizures, chorea, tremors, Cataracts, spasticity, hepatic enzyme disturbance, respiratory tract irritation, renal dysfunction and Cardiac arrhythmias [58].

Cadmium

Cadmium is naturally in inorganic form, which is created by the wear and tear of rocks. Tremendous advances in technology and its use in daily life have increased cadmium levels in soil and water. It is used for electroplating, paints and batteries. Various industrial processes, such as metal smelting, fuel burning and waste disposal through incinerators,

discarded cadmium chloride products and fertilizers, have increased cadmium levels in the environment. This is how cadmium can enter the food chain from the environment [EFSA2004, 2009a]. Cadmium absorption by plants increases with increasing cadmium concentration in the soil. When contaminated plants are used to make poultry feed, it has adverse effects on animals and humans. There is a direct relationship between Cd levels in the diet and Cd concentrations in tissues. Another important factor that influences the Cd concentration in the tissue is the dose and duration of the Cd ingestion [5] . One study also revealed that feed composition has direct effect on its retention of trace elements by tissues [59]. One study done in Khyber Pakhtunkhaw (KPK) Pakistan has showed increased level of cd in eggs and meat of the poultry obtained from different areas of KPK. Additionally It was demonstrated that liver contained increased concentration of cadmium as compared to thigh and breast muscle but concentration of cd in eggs, liver and meat was higher than maximum permissible levels [60] .(There is no essential function of cadmium in human body but has resemblance with many essential metals [61]. It resembles zinc and copper, and iron [62]. It is easily absorbed and distributed in the tissue, which affects the absorption of copper and zinc [NRC2001]. It is easily transported to cells, but it is very difficult to be released from the cell. Cadmium is deposited in the kidneys and liver. Its exposure causes renal toxicity, osteoporosis, CNS toxicity, teratogenesis, cancer and endocrine abnormalities.

Mycotoxin contamination of poultry feed and its adverse effects on human

The word mykin means fungus so “Mycotoxin” means toxin derived from fungus also known as bis-furanocoumarines compounds. These toxic compounds were first discovered in 1960s ([63]. These toxins are well known for their teratogenic, carcinogenic and, mutagenic effect [64], [65].Different species of fungus or molds produce different kinds of mycotoxins such as Aflatoxins ($AF_)$, ochratoxin A (OTA), zearalenone (ZEN), Deoxynivalenol (DON) fumonisins (FUM), trichothecenes are some of the mycotoxins that can significantly affect poultry species through poultry feed .poultry feed is contaminated with mycotoxins due to consumption of contaminated cereals and grains for the preparation of poultry feed [66].

A worldwide survey was performed during 2004-2013 to evaluate the extent of mycotoxin contamination in feeds and feed ingredients. In this study 25,944 samples were collected globally. 85,000 individual analyses were performed, to check the presence of important mycotoxins AF, FUM, OTA, and ZEN [67]. The study found that 76% of the samples contained detectable levels of at least 1 mycotoxin. The research has been published in many peer-reviewed articles[68].

It is already known that contamination of animal feed with mycotoxins in animals can lead to mortality and transmission of mycotoxins to humans through the consumption of eggs, meat or milk [69].

Mycotoxin of poultry feed not only affects chicken health and growth but also contaminate its eggs and meat. In one study analysis were done to find Aflatoxin contaminated feed effect on aflatoxins residue level in eggs, organs (liver, kidney, gizzard) muscles (breast, leg),) and litter. It was seen, that aflatoxin residues were present in eggs, muscles (legs, breast), organs (liver, kidney and gizzard) and litter in noticeable amounts [70]. Mycotoxin transmitted to human through contaminated food stuff causes various grave effects to human health.

Chronic toxicity Symptoms my include gastroenteritis esophageal pain, mucous membrane hyperemia, asphyxiation, laryngitis, and vertigo [69]. Aflatoxicosis is a condition in which person develop hepatitis and jaundice and ultimately death of that person [71]. Aflatoxin in synergistically presence of HBV infection causes liver cancer (Hepatocellular carcinoma) in which (IARC, 1993). The cancer usually develops due to chronic dietary exposure of aflatoxin.

Approximately 250,000 deaths are caused by hepatocellular carcinomas in China and Sub-Saharan Africa annually due to intake of aflatoxin contaminated food and increased prevalence of hepatitis B [72] . Aflatoxins are also thought to cause Kwashiorkor and Reye’s syndrome in children. Aflatoxin exposure caused decreased levels of secretory immunoglobulin A (IgA) in Gambian children [73]. Aflatoxins cause decreased human cellular immunity that decrease resistance to infections.

Radioactive substance in poultry feed

Naturally soil is having different concentration of heavy metals which can cause varying quantity of radioactivity [74]. Earth is exposed continuously to solar radiations and other radiations from different

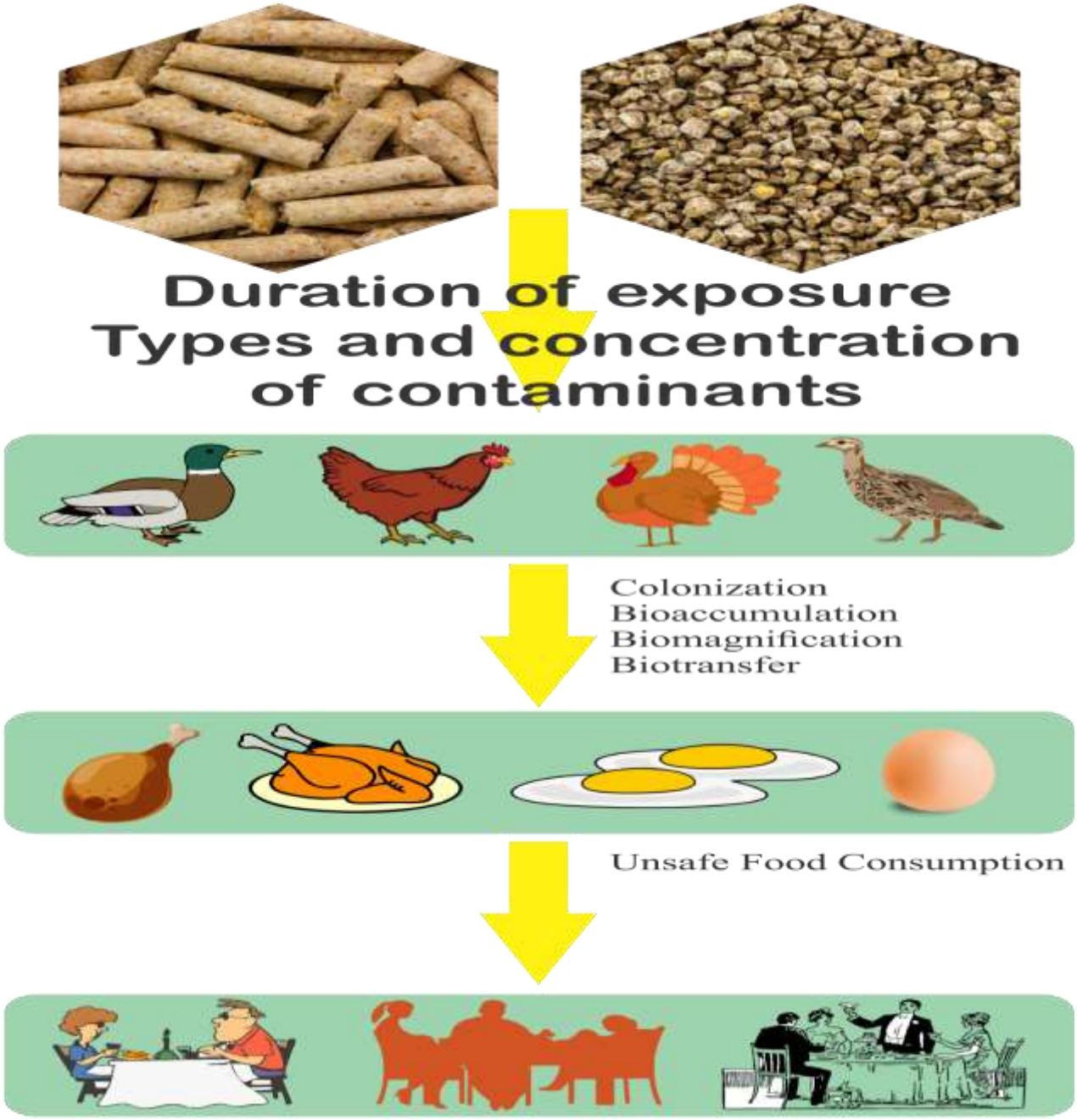

Fig. 2: Safe animal feed-safe food- safeguard human health

sources outside the biosphere, are called cosmic waves [75]. So, every living thing on earth is persistently exposed to small amount of different radiations known as natural back ground radiations. Due to advance technology in nuclear science radioactive substances are being used in medicine, nuclear weapons and nuclear power plants [76]. These radioactive substances are emitting radiations which are harmful for living things. Different plants and animals which are part of food chain are also exposed to these radiations, so are source of transfer of radio nuclides to humans [77]. Forage crops used to make poultry feed can be exposed to radiation from soil, air and groundwater. The rock phosphates used in the manufacture of fertilizers contain a high proportion of uranium, thorium and radium. These fertilizers release radon (a product of rotten uranium) that contaminates the soil. Air and groundwater are finally polluting the

crop. A study carried out in Algeria in 2011 found an increase in radioactivity in the soil where phosphate fertilizers were used compared to the soil where no fertilizers were used [78]. Moreover ground water emits 500 million curies of radon annually worldwide, which act as indirect source of radionuclide [79]. When contaminated crops or water is used to make poultry feed radioactive substance can be transferred to animals [80]. Different vitamins and minerals are added in poultry feed for better growth of animals. Phosphorous is one of the most important minerals for metabolic reactions of living organisms. Dicalcium phosphate (DCP) is added in animal feed for supplementation of phosphate. DCP is mined from phosphate rocks and may contain 238U and its series depending on its nature of source. Different studies revealed presence of varying amount of 238U activity in DCP [81].

As human take eggs and meat so poultry feed should be strictly monitored for the presence of radioactive substance as it may harm human being [82].

Person eating radionuclide-contaminated food will have increased radioactivity inside the body. This will cause increased exposure of internal tissues to radiations. In one study it was estimated that if one year old baby drinks 0.5 L of milk having 100 Bq/L of 131I daily he will have 0.009 mSv more exposure to radiations as compared to others [83] .

The effect of radiations on human being depends upon the type of substance and amount of radiations. Lethal dose of highly radioactive 210 Po (polonium) can be as small as 1μg and can severely affect the kidneys, bone marrow, reproductive system, spleen, digestive tract [84].

Conclusion

Chicken meat has several nutritional benefits and is an inexpensive source of protein-rich material for humans. However, due to the commercialization of the poultry industry, many risks to human health can arise if adequate supervision and care are not applied during the production process. Feeding birds can be a tremendous source of toxic contamination. This contamination not only causes animal health problems but can also be dangerous for humans. Poultry feed must therefore be consumed and marketed after adequate experimental analysis, otherwise it can cause many potential risks for animals and, ultimately, for people who consume meat and eggs (**Fig. 2**). The government must therefore take strict measures to implement food safety laws in the poultry industry.

Author's contributions

Dr. Saima Suleman substantially contributed in conception and designing this review article. Dr. Arif Malik supervised in writing this manuscript. Dr. Majeeda Rasheed, and Waqas Farooq participated in reviewing the document and development of this manuscript.

Conflict of interest

The authors declare no conflict of interest.

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