Tetracycline Antibiotics Applications in Agricultural Practices and Their Effects on the Environment: A Review

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ABSTRACT

Medical applications of tetracycline antibiotics to animals, plants, and people helped the well-being of living organisms protected them from several diseases. However, large quantities of tetracycline antibiotics can be secreted with animal dungs and contaminate the environment (soils, surface waters, and ground waters). These antibiotics also exert selection pressure on soil/water bacteria and promote development of antibiotic resistance. This review article shows the side effects of using tetracycline antibiotics on soil, surface and ground waters, human health, and the influence on worldwide economy. It is recommended to reduce the use of antibiotics as well as apply antibiotics waste management strategies in order to minimize their environmental risks.

Key Words: Antibiotic Resistance, Environment, Soil, Surface and Ground Waters, Global Economy.

INTRODUCTION

The discovery of tetracycline antibiotic was important for the treatment of people and animals (CDCP, 2013; Anonymous, 2014). About $13.5x10^6$ kg of antibiotics have been consumed worldwide by animals in 2011 as reported by the United States Food and Drug Administration (USFDA, 2010). Tetracycline was discovered in 1950s (Nelson *et al*., 2011). The tetracycline chemical formula consists of four fused cyclic rings with attached functional groups. Figure 1 shows the chemical structure of oxytetracycline, which is one of tetracycline type antibiotic.

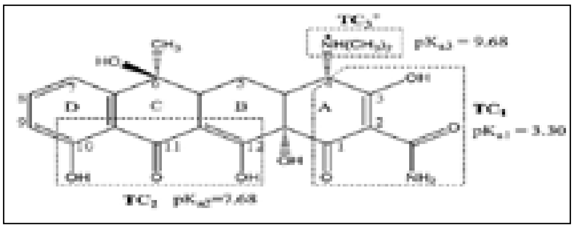

Figure 1: Chemical structure of oxytetracycline antibiotic with three pKa values (Zhao *et al*., 2012).

Tetracycline antibiotics have enormous usages for protecting human and animal from many infectious diseases. In 2011, use of tetracycline included 42% of the total antibiotics utilized in the zoological foods, about 5.6 million kg of tetracycline as declared by U.S. Food and Drug Administration (USFDA, 2010). Since high doses of tetracycline antibiotics are not digested in the animal, vast quantities of tetracycline antibiotics are excreted with animal dungs such as parent compounds or bioactive metabolites (Plósz *et al*., 2010). Therefore, tetracycline antibiotics can survive longer in soil or leach to surface water, and groundwater (Hu *et al*., 2010).

Though the concentrations of tetracycline discovered in many environmental media are lower than the minimum levels of inhibitory concentration (MIC) for medicinal interests, the detected levels of tetracyclines in the environment perhaps discriminate among bacteria by emphasizing populations. Thus, bacteria with antibiotics resistant genes can survive and enrich antibiotic resistance of bacterial populations in the environment (Zhang *et al*., 2014).

In 2014, the World Health Organization published an advisory report, in which they declared that humans are in danger of finding themselves in a post-antibiotic era. The report has indicated that doctors are unable to fight infections like drug-resistant gonorrhea, and that modern treatments are needed to substitute for the drugs which became ineffective due to bacterial resistance (WHO, 2014). The usages of antibiotics are growing but still imperfect to hold up with the resistance of bacteria (Jarvis, 2014). The bacterial resistance is complex, and it includes many features which can cause various diseases against human and animal (WHO, 2014).

The objective of the current review article was to draw attention to the environmental risks of excessive uses of tetracyclines and other antibiotics in agricultural practices. Furthermore, the article listed some resources of tetracycline antibiotics and their fate in our environment and then some of their effects on soil, surface and ground waters, human health, and their influence on worldwide economy.

ANTIBIOTICS USAGE ON PLANTS

Microbial diseases of agricultural crops have huge influences on plant production, and rare tools are obtainable to alleviate plant damage (Stockwell and Duffy, 2012). The discovery of tetracycline antibiotics brought the hope of combatting many microbial diseases of agricultural crops (Dunegan *et al*., 1954; Goodman, 1954; Stockwell and Duffy, 2012). Roughly, 40 bacterial antibiotics were examined for disease of plant control (McManus *et al*., 2002). The main goals of using antibiotics on plants were to stop different bacterial ailment of greens, pear, and apple fire blight (Goodman, 1954; McManus *et al*., 2002; Stockwell and Duffy, 2012). Unfortunately, the appearance of anti-bacterial strains to antibiotics can reduce their efficiency (McManus *et al*., 2002; Stockwell and Duffy, 2012). More than 30 different antibiotics are applied on agricultural plants in the United States (Stockwell and Duffy, 2012). Since the antibiotics are very expensive, they are applied mainly on greens and fruits that have high values (Vanneste, 2000; McManus *et al*., 2002).

OXYTETRACYCLINE (A TETRACYCLINE ANTIBIOTIC)

In the United States, oxytetracycline or the tetracycline antibiotic is registered for controlling *Erwinia amylovora* on pear and for controlling *Xanthomonas arboricola* that can cause bacterial spots on nectarine and peach (Christiano *et al*., 2010; Stockwell and Duffy, 2012). Likewise, oxytetracycline is used to protect the Mexico apple from *Erwinia amylovora*. In addition, a small amount usage of oxytetracycline is applied into palm trunks and elm plants for protecting them from lethal yellows diseases that can cause via phytoplasmas (McCoy, 1982; Stockwell and Duffy, 2012).

ANTIBIOTICS AMOUNTS USED

Around 65,227 kg of antibiotics are used for plant protection in the United States annually. (McManus *et al*., 2002). In addition, the quantity of antibiotics that is applied on plants in the United States is about 0.5% of total annually antibiotics production (Sarkar *et al*., 2018).

Table 1 shows variation consumptions of tetracycline antibiotics in livestock in ten different countries. Globally, around 7,092.6 tons of tetracycline antibiotics were consumed annually in livestock (Daghrir and Drogui, 2013); where the United States was the largest user of tetracycline antibiotics (3200 tons yearly), because it has a huge number of livestocks, as well as using tetracycline antibiotics widely as growth promoters (Daghrir and Drogui, 2013).

Table 1: Total variation consumptions of tetracycline antibiotics used in livestock in different ten countries (Daghrir and Drogui, 2013).

Country	Total Amounts (Tons)Tetracycline Antibiotics Used in Livestock
U.S.A.	3200
Europe	2575
Korea	723
U.K.	228
France	117
Denmark	13
Brandenburg	4.6
Sweden	2.7
Switzerland	1
Norway	0.3

USAGE OF ANTIBIOTIC ON FRUIT PLANTS

Broadly, the biggest usage of antibiotics in plants has been to dominate the fireblight disease of pear and apple. Fireblight disease can be controlled by usage of oxytetracycline through flowering time. Overall, around 40% of pear productions treated by oxytetracycline 2 to 4 times a year, also 10% of peach productions treated by oxytetracycline (McManus *et al*., 2002; Stockwell and Duffy, 2012), and almost 10.5% of apple lands treated yearly by oxytetracycline (Willett *et al*., 2014).

ORGANIZATION OF ANTIBIOTICS USES

The United States Environmental Protection Agency (U.S. EPA) organizes the tetracycline antibiotics usages for crops or plants in the United States. Other countries have governmental agencies similar to the U.S. EPA (McManus and Virginia, 2001, Stockwell and Duffy, 2012). In the United States, the recording procedure for any pesticide involves estimating the possible chemical influence or effect on human health. Oxytetracycline antibiotic has been specified as lowest toxicity within U.S. EPA category (Stockwell and Duffy, 2012). Studies showed that the residue tolerance concentration of oxytetracycline on tree fruit plants was 0.35 ppm. (Edwards, 2006; Stockwell and Duffy, 2012).

ARGUMENTATIVE SIDES OF ANTIBIOTICS USE ON CROPS

Does agricultural antibiotic enhance antibiotic resistance in humans? The usage of antibiotic in livestock production takes around 40% of total antibiotic usage in the United States (Levy, 1998, Stockwell and Duffy, 2012). Though the amount of antibiotics used on crops or plants is so small, massive expanses of the agricultural areas may lead to increase resistance of antibiotic frequency in genetic factor pool and the hierarchy of food (Stockwell and Duffy, 2012).

VETERINARY ANTIBIOTICS FATE IN SOIL

Since huge quantities of veterinary antibiotics have been used in livestock, antibiotics can reach agricultural soil via animal manure. Thus, those antibiotics may raise the abundance and mobility of antibiotics resistance genes (Kumar *et al*., 2005; Jechalke *et al*., 2014; Grenni *et al*., 2018). This, scenario may cause humans' pathogens development that progressively threaten the profitable antibiotic remediation of bacterial contagion (Jechalke *et al*., 2014; Woegerbauer *et al*., 2015; Grenni *et al*., 2018). Maximum concentrations of tetracycline and oxytetracycline antibiotics reported in animal manure were 98,000 and 354,000 µg/kg, respectively (Cycoń *et al*., 2019). Moreover, maximum concentrations of tetracycline and oxytetracycline antibiotics reported in soil were 2,683 and 50,000 µg/kg, respectively (Cycoń *et al*., 2019). In the United States, the amount of antimicrobials used in animal feed is roughly higher than for usages by humans. However, the use of antibiotics in either animals or humans has a similar effect of raising the hazard of bacterial resistance evolution (Jechalke *et al*., 2014).

Several studies indicated that the fate and environmental transformation/degradation of any antibiotic in soil relies on its chemical structure, physico-chemical characteristics of antibiotic such as molecular weight, water solubility, distribution coefficient (K_d), soil organic carbon-water partitioning coefficient (K_{OC}), and octano-water partition coefficient (K_{OW}) (Cycoń *et al*., 2019). In addition, degradation of antibiotic relies also on soil properties like soil type and texture, organic matter, pH, moisture, temperature, and oxygen status (Cycoń *et al*., 2019).

In fact, antibiotics compounds react with the solid phase of soil, so they are liable to microbial transformations such as sulfonamide, which is used intensively in animal production (Jechalke *et al*., 2014; Grenni *et al*., 2018). Thus, the manure and excretion of those animals may have some amount of the same parent compound that was not metabolized by animal body (Jechalke *et al*., 2014). Possible antibiotics transmissions from soils to the air, hydrosphere, or even biosphere. Since pharmaceuticals have a very small vapor pressure, so volatilization cannot be considered as their fate in soil. Surface runoff might scatter antibiotics in our environment. Leaching or the vertical leakage to groundwater. The highest portion of many antibiotics used for soil with animal excretion is generally conserved in soil surface (Jechalke *et al*., 2014; Gothwal, and Thhatikkonda, 2015; Grenni *et al*., 2018). In addition, many pharmaceuticals will consume by crops and plants (Jechalke *et al*., 2014; Tasho and Jae, 2016; Carter *et al*., 2016), however concentrations of pharmaceuticals in plants are very small. Therefore, plant uptake may not be used as a strategy for removing of antibiotics (Jechalke *et al*., 2014).

Adsorption and desorption processes control the mobility, plant uptake, biotransformation, and biological influences of veterinary antibiotics. Moreover, a pH function has a hug impact on the speciation and charges of most antibiotic compounds (Aminov and Mackie, 2007; Kümmerer, 2009; Jechalke *et al*., 2014).

ECOLOGY AND TRANSFORMATION OF TETRACYCLINE RESISTANCE

Usage of tetracycline antibiotics through the years was accompanied by an extreme growth in terms the tetracycline resistance frequency in a vast scope of microorganismal species and genera (Levy and Novick, 1986; Johnson and Adams, 1992; Wan *et al*., 2013). A resistance variety determinant is detected in the bacterial cosmos, pointing to various resistance mechanisms. Also, the last analysis for a single family of resistance factors gives proof for intragenic evolutional alterations (McMurry *et al*., 1980; Johnson and Adams, 1992). In the environment, tetracycline manifests a very stable compound, and is not broken usually via resistant strains! but ampicillin can break it. The activity of tetracycline in human samples and rodent manure, which were stored at room temperature, did not reduce even after months. However, environmental pollution via tetracycline might have a progressive effect (Johnson and Adams, 1992; Wan *et al*., 2013).

TETRACYCLINE RESISTANCE GENES

Overall, resistance genes were and still in our environment before using tetracycline antibiotics (Perry *et al*., 2014; Forsberg *et al*., 2014; Wang *et al*., 2017). In addition, many resistance genes have been reported in several types of foods (Osimani *et al*., 2017), which are the major path for resistance genes of antibiotics and microbes to enter a human body (Rolain, 2013; Wang *et al*., 2017). Moreover, the tetracycline antibiotics resistance genes can move from soils to livestock animals through food or vice versa (Wang *et al*., 2017). Therefore, bacteria in the environment has a significant role because it can receive and obtain resistance genes of antibiotics. Majority of those resistance genes remain unknown and cannot be identify by traditional methods such as PCR because this method depends on known sequences (Wang *et al*., 2017). However, until this time, fifty types of tetracyclines resistance genes have been recognized (Roberts, 2005; Thaker *et al*., 2010; Wang *et al*., 2017).

TETRACYCLINE RESISTANCE SOURCE

Tetracycline usages in human health and livestock is a recent process. However, resistance of tetracycline agents has been discovered in strains confined prior the popular tetracycline usages via humans. Tetracycline is produced by some types of *Streptomyces* members (Ohnuki *et al*., 1985; Johnson and Adams, 1992). Tetracycline resistance have been developing through several decades, probably in reaction to contest with other organisms which can produce substances that are very like to tetracycline (Johnson and Adams, 1992).

INFLUENCES OF ANTIBIOTIC ON SOIL MICROBIAL AND ENZYME ACTION

Antibiotic is produced to fight bacteria in either humans or animals for protecting them from spectrum diseases (Sarmah *et al*., 2006). After a remediation process, amounts of antibiotics are discharged from human and animal bodies as unchanged or metabolized compounds, but most excreted substances are still having a biological effect (Sarmah *et al*., 2006; Liu *et al*., 2009). The predominant environmental path of antibiotics release is the usage of animal manure also bio-solids consisting of discharged antibiotics into agricultural ground as compost. In addition, antibiotics can go into agricultural ground via irrigation using recycled wastewater (Göbel *et al*., 2005; Kemper *et al*., 2008). If the antibiotics leak to the soil or cultivated lands, they may influence plant development in addition to activity of soil microbes. High antibiotics activity in soils will prevent the development of soil microbes and will affect the composition of microbial community in soil. Therefore, this may change environmental soil function (Cycoń *et al*., 2019). The antibiotics impact on crops in soils were discovered to vary from compound to another as well as between crops species (Liu *et al*., 2009). For example, tetracycline increased the radish harvest while it decreased the pinto bean harvest (Batchelder, 1982).

Several studies have observed that even little levels of antibiotics can affect many soil processes that have been mediated via microbes (Cycoń *et al*., 2019). Antibiotics applications to soils can also influence soil respiration, nitrification and/or denitrification rates, biogeochemical cycle and turnover rate of Fe(III) in soil (Cycoń *et al*., 2019).

Another study showed that tetracycline has a little impact on respiration of soil microbes, with considerable differences only noticed at very high concentrations rates (Liu *et al*., 2009). On the other hand, the same study also showed that antibiotic sulfonamides was observed to cause meaningful declines in respiration of soil during only 4 days. Also, a further study showed that activity of microbes decreased via antibiotic sulfonamides through 4 days after compost application (Kotzerke *et al*., 2008). Furthermore, Kotzerke *et al*. observed that tetracycline has no influence on respiration of soil because of sorption or degradation process that can reduce the impacts of antibiotics (Liu *et al*., 2009). In addition, tetracycline has shown a strong sorption upon soils. Therefore, the tetracycline antibiotic has a low bioavailability. Moreover, the tetracycline has a very strong sorption with cation. For example, it can form complexes with calcium, magnesium, and sodium in soils (Zielezny *et al*., 2006; Pils and David, 2007). Thus, this may decline the tetracycline bioavailability and its impacts on respiration of soil microbes (Liu *et al*., 2009). Parameters of microbes like enzymatic activity might be affected through different factors, and these parameters could not be specified for antibiotics influences in soils (Liu *et al*., 2009).

CONTAMINATION THROUGH ANTIBIOTIC RESISTANCE GENES

Some studies showed that contamination of antibiotic could enhance the community of resistant microorganisms. Thus, it will decline the sensitive microbial community (Martinez, 2009). Commonly, a very high level of antibiotic concentration could be discovered in sludge water as well in soil that is mixed with animal compost and field soil. Nevertheless, this high concentration level is generally centered to zones of humans practices while untouched environment has a very small antibiotic concentration (Pallecchi *et al*., 2008; Martinez, 2009). Genes of antibiotic resistance were discovered globally, and they can be estimated because of their native in microbial environment. However, the vast spread of genes greatly appear in infected humans at areas without large pressure of antibiotics, so the likelihood for genes conservation in normal ecosystems could be great. Therefore, genes of antibiotic resistance were treated like contaminants themselves (Martinez, 2009).

VETERINARY ANTIBIOTICS IN SURFACE AND GROUND WATERS

Land usages of cattle and people waste manure are widespread agricultural activities. However, those organic modifications could include groups of different antibiotics, pathogenic bacteria, or even antibiotic resistant genes (ABR) (Chee *et al*., 2009; Heuer *et al*., 2011). Pollutants came from animal excretion and bio-solid use can transfer quickly from soil surface to the groundwater as well as neighboring resources of water which would discompose hazards the environment and humans health (Hoang *et al*., 2013; Pinheiro *et al*., 2013).

Furthermore, worry was growing about the possibility of veterinary antibiotic influence on antibiotic scales in our environment that would be intensified in either soil or water regimes. In addition, that could happen in different situations of the environment (Zhang *et al*., 2009; Pruden *et al*., 2013; Frey *et al*., 2015). For instance, a study discovered a tentative accretion in bacterial antibiotic resistance in soil due to exposure to tetracycline that came from usages of swine excretion. Also, another study discovered that sulfadiazine, associated with manure, enhanced antibiotic resistance of silt loam soil as well loamy sand soil during 2 months (Sengeløv *et al*., 2003; Heuer and Smalla, 2007).

Structure of soils and tile drainage would reduce the normal filtration abilities of soils for vast groups of water pollutants. In addition, previous study discovered that favored flow into tile drains is a valuable transfer technique of antibiotics (Kay *et al*., 2004; Lapen *et al*., 2008). Since drainage is primarily developing plant productions in vast areas, useful management activities effectively reduced the off –field tile water pollutants motion, like managed tile drainage, demand to be examined to value their capability to decrease antibiotics transfer, pathogens, as well the genes of antibiotic resistance to surface and ground waters. Therefore, managed the tile drainage can be a possible scenario to decrease the releasing of either organic or inorganic pollutants from drained agricultural lands following animal excretion applications (Frey *et al*., 2013; Frey *et al*., 2015). Several studies recommend reducing amount of antibiotics usage and suggested to follow good strategies of antibiotics wastes management such as treatment of wastewater conservation of drinking-water catchment regions, soils management, disinfection, arrangement of sewage application, and bioremediation (Goulas *et al*., 2018).

HUMAN EXPOSURE TO AGRICULTURAL ANTIBIOTICS

Antibiotics are used in agricultural crops to protect them from spectrum bacterial diseases, and around 0.1% of the total antibiotics production was applied to agricultural crops (Willett *et al*., 2014). Pollution of antibiotics is a serious matter in organic vegetables, due to food security crisis (Hu *et al*., 2010). Universally, contagions of bacteria in human that are antagonistic to antibiotics persist to form a serious threat (Centers for Disease Control and Prevention, 2013). Several bacterial resistance were reported in farming habitats, and they would affect people by either food ingesting or further complicated environmental exposure pathways. Agricultural activities have the largest contribution to the development and steadfastness of antibiotics resistance (Singer and Williams-Nguyen, 2014).

Connotations between antibiotics usages in livestock and the occurrence of bacterial antibiotics-resistance secluded from these animals have been noticed in both experimental researches and in random trials. Also, bacterial antibiotics-resistance of animal source have been detected in both the environment that is near to those livestock and their products in marketplaces. Thus, they will be sources of bacterial diseases and infections in people (Landers *et al*., 2012).

Random usage of antibiotics in agricultural practices leads to excessive threats to human health. In addition, some studies argued that the quantity of antibiotics used in agriculture could be close to the amount that used via humans due to increase of bacterial antibiotics–resistance. This caused hardship in treating of bacterial medicine-resistance infections in humans (Marshall and Levy, 2011; Sarkar *et al*., 2018).

Another study showed probable associations between antibiotics usage in agricultural activities and human diseases. A first likely link is that direct bacterial spread that not modified to transition in a human by the food chain (such as *Campylobacter* and *Salmonella*) or straight interaction with animals. The second possible link is that direct spread of microbes previously adjusted to transition in a human. And the third potential relation is that resistance genes transfer from the farmlands into pathogens transferring amid humans (Chang *et al*., 2015).

One of the newest studies have measured the deaths number from bloodstream contagion that occurred through the third generation of *Escherichia coli* (cephalosporin resistant) which resulted from antibiotics usage, primarily cephalosporin in chickens' productions (Collignon *et al*., 2013). Another study discovered that around 56% of genes resistance in the third generation of *E. coli* in people were similar to those genes that originate from *E. coli* insulated poultry samples (De *et al*., 2011). Actually, antibiotics uses in agriculture lead to raise the resistant pathogens. Therefore, these pathogens will transfer to the people through food series or to the environment (Singer and Williams-Nguyen, 2014).

Some studies reported levels of tetracyclines antibiotics in crop tissues ranged from 1 to 50 µg/kg. These concentrations increased with time and the quantity of tetracyclines antibiotics that are present in animal manure (Hu *et al*., 2010). Furthermore, a study discovered that winter has huge environmental threats because antibiotics residues from animal manure, soils, vegetables, and ground waters were much higher than in summer season because winter is a very important period for antibiotics application to vegetables (Hu *et al*., 2010).

In addition, the same study found that levels of tetracyclines antibiotics were highest amid different antibiotics in vegetables (Hu *et al*., 2010). This indicates that residues of tetracyclines antibiotics in vegetables are a serious threat to human and environmental health. Some studies showed that no evidence of oxytetracycline residue noticed in apples and pears fruits (Willett *et al*., 2014). However, fate of tetracyclines antibiotics in fruits, which are consumed by human, needs further investigations and studies.

RESIDUE OF CHLORTETRACYCLINE CONCENTRATION IN CHICKEN EGG

Poultry companies are growing rapidly. Yearly, the growth rate of poultry companies is around 10% in India, so poultry has an important role in linking the animal protein gap in many countries (Mumtaz *et al*., 2000). The use of new planning regimes, arrangement with modern technologies have allowed a stable growth in chickens' productions. Amid those technologies would be small doses of antibiotics to promote the growth, high levels of doses for remediation, and moderate levels of doses for inhibiting diseases (Kodimalar *et al*., 2014). Antibiotics uses enable the consumers to buy very good meats and eggs within a plausible price paid (Donoghue, 2003). Thus, these antibiotics accumulate in body tissues and productions like eggs (Donoghue and Hairston, 2000). One study mentioned that antibiotic chlortetracycline is mainly used in chickens' diet (Al-Mustafa and Al-Ghamdi, 2002), so that antibiotic would transport from diet to eggs. In addition, chlortetracycline detected in numerous of marketing chickens' farms (Kodimalar *et al*., 2014).

RESIDUE OF TETRACYCLINE IN PASTEURIZED MILK

Surveillance residue of antibiotics in dairy milk in Brazil is a condition in accordance with the formal standards for products, treatment, and trading of milk, also matching the global standards (de Albuquerque *et al*., 2014). The antibiotics used to treat cows might cause antibiotic residue in dairy milk. Furthermore, in Brazil, a study showed certain residue of antibiotics that was around 4% (Fonseca *et al*., 2009; de Oliveira *et al*., 2012), using screening tests since antibiotics use in livestock, particularly to dominate the mastitis disease (Bansal *et al*., 2011; de Albuquerque *et al*., 2014). A recent study showed that the extreme tetracycline residue level was 100 ng m/L (Codex, 2012). When residue of antibiotic present in the dairy milk, this might make hypersensitive phenomena, like toxic impacts and the evolution of microorganisms' resistance to antibiotic (Stolker and Brinkman, 2005; Gao *et al*., 2012). Therefore, this scenario will make the dairy productions a source of hazard to the people (Can and Celik, 2012; de Albuquerque *et al*., 2014).

ANTIBIOTIC RESISTANCE EFFECTS IN A GLOBAL ECONOMY

Some studies observed that the better way to predict *Shigella* resistance was via the patient history of traveling abroad (Tauxe *et al*., 1990; Rabaa *et al*., 2016). The global traveling would make transport of bacteria very frequent, and then this may increase bacterial resistance. Hence, the antibiotic usage in a specific country influences the people in another country (Cohen, 1992, Rudholm, 2002). In addition, there are several studies argued that pharmaceutical companies lose portion of their economic motivation to improve modern antibiotic elements (Liss and Batchelor, 1987; Ventola, 2015). Furthermore, a recent study mentioned that national price paid because of the antibiotics resistance in the United States alone ranges from \$55 to \$70 billion yearly (Li and Webster, 2018). In fact, the antibiotic resistance rises costs of people healthcare and extend the hospital stay period (Gulen *et al*., 2015). By 2050, a new report showed that the number of deaths would reach to 10 million due to antibiotic resistance (O'Neill, 2017). Thus, the countries will lose around 100 trillion U.S. dollar from their incomes (O'Neill, 2017).

CONCLUSIONS

In summary, antibiotics like tetracyclines, used excessively in livestock and farms, have different effects on our environment since antibiotic can excrete from a treated body to the environment as its parents or original material without any change. Then, antibiotics will move from soil to surface water and ground water. These antibiotics react with several kinds of microorganisms, so they may contribute in develop resistance of microorganisms to antibiotics. This scenario will affect soil microbial community, water quality, human health, and global economy, so we would lose the ability to control bacterial diseases. In addition, we recommend decreasing quantity of antibiotics usage and following good strategies of antibiotics wastes management such as treatment of wastewater conservation of drinking-water catchment regions, soils management, disinfection, arrangement of sewage application, and bioremediation in order to minimize environmental risks of antibiotics.

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استعمالات المضادات الحيوية التتراسيكلين في الممارسات الزراعية وآثارها على البيئة
مقالة مرجعية

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الملخص

استعمالات المضادات الحيوية التتراسيكلين على الحيوانات والنباتات وصحة الناس قد حفظت الكثير من الكائنات الحية وحمتها من أمراض عديدة. ومع ذلك، يمكن أن تكون المضادات الحيوية التتراسيكلين مصدراً للملوثات الناشئة في البيئة بسبب الكميات الهائلة من المضادات الحيوية التتراسيكلين التي يمكن إفرازها مع روث الحيوانات وبالتالي يمكن أن تلوث التربة والمياه السطحية والمياه الجوفية. تشكل هذه المضادات الحيوية أيضًا ضغطا انتقائيا على بكتيريا التربة/ الماء، وتحفز تطور سلالات مقاومة للمضادات الحيوية. وقد عرضت هذه المقالة العلمية الآثار الجانبية لاستخدام المضادات الحيوية التتراسيكيلين على التربة، والمياه السطحية والجوفية، وصحة الإنسان، والتأثير على الاقتصاد العالمي. وأوصت الدراسة بتقليل استخدام المضادات الحيوية واتباع استراتيجيات جيدة لإدارة نفايات المضادات الحيوية من أجل تقليل مخاطرها البيئية.

الكلمات المفتاحية: الاقتصاد العالمي، البيئة، التربة، مقاومة المضادات الحيوية، المياه السطحية والجوفية.