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Water Quality for Some Vegetable and Livestock Husbandry Farms in AlQurayyat, KSA: Current Status and Future Aspirations

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ABSTRACT

A survey has been done and detailed account has been given of the physicochemical and bacteriological properties of the drinking water used in 3 small scale poultry, 3 small scale sheep and 7 large scale vegetable farms in AlQurayyat, Al-Jouf Region, Saudi Arabia. One of the objectives of the study was to raise the awareness of the population about the challenges facing the agricultural sector in such amazing geographical and security area. There are two small scale licensed poultry meat farms, namely AlQurayyat Poultry Farms, with a daily production of 2500 chicken. Moreover, 30 unlicensed small scale poultry meat farms were encountered. However, no egg-producing farms were found. Field trips revealed that there are about one hundred small scale sheep farms, with the members of each herd ranged between 50 and 200. The pH values were located on the weak alkaline scale. The total dissolved solids (TDS) varied greatly among studied water samples. Concerning the vegetable cultivation, TDS ranged between 1600 and 7008 mg/L. These findings indicate that the water in some farms was invalid. Out of 13 examined water samples, 4 were contaminated with bacteria. Turbidity levels were relatively high and varied clearly among the studied water samples; they ranged between 0.17 and 8.7 NTU colour units. The levels of sulphate, phosphate and nitrate salts showed marked variability. Five out of 7 water samples used in crop irrigation attained sulphate levels over 150 mg/L. Iron gradient ranged between 0.05 and 0.12 mg/L. Data obtained revealed that nitrite levels of the studied water samples were safe; it ranged between 0.007 and 0.354 mg/L. The relationship between water quality and livestock well being is clarified. Future aspirations and planning to improve the quality of water and meet the growing demand for meat, milk and eggs of the ever growing population in AlQurayyat are discussed in detail.

INTRODUCTION

Groundwater is the water accumulating beneath the surface of the ground and is formed primarily of the surface water seeping down at frequent time intervals. It is brought to the land surface by wells, aquifers and springs. Groundwater exhibits shallow or deep flow path according to the direction of the movement and termination place. On the one hand, shallow groundwater flow (groundwater runoff) communicates the land surface, feeding springs and seeping back to the surface waters. On the other hand, deep groundwater flow (groundwater runout) moves directly into the ocean without any contact with the land surface. Surface waters are generally fresh, fairly new and recycle every 11 days (World Water Balance, 1978), with evaporation, evapotranspiration and surface runoff are the key factors driving the rapid recycling of the surface water. The salinity of freshwaters is less than 500 ppm, while the salinity of ocean waters is about 35,000 ppm. Irrigation water is slightly saline water and shows TDS value from

500 to 1,500 ppm. Drainage water and groundwater are moderately saline and attain TDS range from 1,500 to 5,000 ppm. Highly saline groundwater may have salinity gradients more than 5,000 ppm (Wallender and Tanji, 2011).

The human population and livestock in AlQurayyat depend merely upon the groundwater mined from the Disi aquifer for drinking, household and irrigation purposes. Water abstracted from the ground wells is characterized by high water alkalinity and hardness caused by increased gradient of minerals. Moreover, broiler farms experiencing flock performance problems contained high levels of sodium, potassium and iron (Oviedo, 2006). Water is the most important nutrient for broiler performance. Water constitutes 55-75 % of the hen's body and 65 % of an egg. It softens and hydrolyzes feed items to facilitate their digestion. It regulates body temperature and being a magic agent in all biochemical interactions. Sanitation and acidification are two common and highly important practices implemented to improve water quality for the broiler performance.

The poultry production in KSA is growing rapidly to meet the animal protein demand of the ever growing population. Moreover, the primary goal of the Saudi government is to achieve self-sufficiency in poultry meat production. Poultry meat consumption of the kingdom recorded 640000 million tons in 2014. This industry is promising as it provides the community with low price and valuable source of the animal protein. GAIN report (2014) demonstrated that the poultry production in KSA meets about 42% of the broiler meat consumption of the community. The overall poultry production was 1.44 million tons. However, the cost of poultry feed and high mortality rates are two challenges facing the Saudi poultry sector. The poultry import market in KSA has been flourished over the last decade, with a total import burden of 875.259 million tons. Brazil is the first exporter of the frozen chickens with a sharing ratio of 79% in the poultry import market. France comes second and attains a sharing ratio of 18%.

Raising sheep is one of the most important livestock industries in Saudi Arabia. Sheep farming provides milk, meat and wool. Sheep are relatively small in size, easy to handle and live in a narrow space. Their manure is utilized as a fertilizer to enrich the poor soil. Moreover, sheep graze on low quality pasture, and eat brush, grasses and weeds that grow in poor soil. Sheep are grazers and prefer to eat grass, clover and weeds. They also eat a mixture of plants unpalatable for other livestock. Protein requirement is only about 8 to 10% of the sheep diet. Sheep dip is a liquid formulation of insecticide and fungicide utilized by farmers to protect the herd of sheep from infestation against ectoparasites. Sheep dip can cause a great deal of damage to groundwater. Sheep dips have been found to cause soil contamination and water pollution (Info Sheet, 2003; Dewar *et al*., 2004). They contain chemical insecticides that are highly toxic to aquatic plants and animals (Environment Agency, 2012). For this reason, it is important that the dip and dipped sheep should be properly managed to avoid spreading the chemicals and causing water pollution. In this respect, regular inspection and prevention of the possible leaks or drain holes are appreciated.

The main objective of the present study is to highlight irrigation and drinking water quality criteria in some vegetable farms, small scale poultry and sheep farms in AlQurayyat, Al-Jouf Region, northern Saudi Arabia. One of the objectives of the study is to raise the awareness of the population about the challenges facing the

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agriculture and animal wealth sector in such amazing geographical area.

MATERIALS AND METHODS

Water Sampling and Analysis:

A total of 3 drinking water types for indoor poultry performance, 3 drinking water types for small scale sheep farming and 7 water types used for irrigation of widely spread vegetables. All water samples were abstracted from private wells (Figure 1) that are operating improperly. In many occasions, a small temporary storage concrete reservoir was recognized nearby the outlet of the well (Figure 2). Water samples were collected and processed according to the method described in El−Naggar (2015). Chemical and bacteriological tests were conducted at the laboratory of the water purification plant in AlQurayyat. HACH DR/5000 Portable Spectrophotometer was used for the measurement of nitrate, nitrite, phosphate, iron, sulphate and total chlorine.

Total dissolved solids (TDS) were determined with the aid of HQ14d HACH Conductivity Meter. TDS values were expressed as milligrams per liter (mg/L) or part per million (ppm). Turbidity (or transparency) of the water samples was measured by 2100Q01 HACH portable Turbidimeter (Ultrameter). Hydrogen ion concentration (pH) is a measure of the acidity or alkalinity of the drinking water in the present study. Water with a pH less than 7 is classified to be acidic and water with a pH more than 7 is considered to be alkaline. Pure or neutral water attains a pH level close to 7.

RESULTS

Large scale vegetable cultivation in AlQurayyat:

A wide range of vegetables are successfully grown in AlQurayyat. The major vegetable crops include coriander (Figure 3), parsley, dill, pepper, tomato, cucumber, eggplant, onion, watermelon, and squash. In addition, forage crops (alfalfa) as well as palm and olive trees are abundant. There are two irrigation methods in AlQurayyat farms: waterwheel and circle irrigation and surface or flood irrigation. Most center pivots and their water supplying wells are operated by aging diesel engines emitting a range of pollutants, which may leak into the water stream flowing into the cultivated land. No planned drainage systems were recognized in AlQurayyat. All the studied vegetable farms obtained their irrigation water from private, unlicensed wells which are primitive and are not covered by any local or regional regulations that protect irrigation water systems. Salt deposits were frequently recognized on the ground (Figure 4).

Small scale sheep farming in AlQurayyat:

AlQurayyat showed an intensive sheep farming nowadays. Sheep farming is a livelihood of thousands of people in such amazing region. Hundreds of sheep farms comprising herds are available in AlQurayyat and are regarded as an important source of organic homegrown meat (food) or earning a living from their products (wool, leather, meat and milk). Field trips to the sheep farms indicated that the number of individuals in a herd ranges between 50 and 200 (Figure 5).

Chicken-indoor husbandry system in AlQurayyat:

There are two large poultry meat farms, namely AlQurayyat Poultry Farms. They are located nearby Kaf Village, 20 Km northeast AlQurayyat City (Figure 6). The daily production of the two farms is approximately 2500 chicken (about 900000 chicken per year). The daily production fluctuates according to the season and health status of the broiler population. The fodder mix is provided by Orascom Company and comprises yellow maize, soybeans and protein concentrates. Biosecurity, refers to procedures

followed to prevent the introduction and spread of pathogenic organisms in poultry flocks, was a priority in AlQurayyat Poultry Farms. Daily biosecurity measures were practiced to reduce the possibility of introducing infectious diseases such as Avian Influenza, Broncitis, Gumboro, and Exotic Newcastle, etc.

Field trips to AlQurayyat Poultry Farms revealed that many standard measures were applied to increase the biosecurity of the flocks. Visitors were kept to minimum, visitations to the other poultry farms were limited, flocks were inspected daily, the environment was optimized, equipments and vehicles entering and leaving the farm were disinfected with ammonia, Iodine and/or formaldehyde, areas around houses and feed basins were cleaned thoroughly, and only one worker served one house. The growing cycle for broilers in AlQurayyat Poultry Farms was 40 days. Each growing cycle is followed by 10-days period for disinfection. Each chicken consumes 3000 gm fodder throughout the cycle.

Data concerning the physicochemical properties of the studied water types are recorded in Tables 1, 2 and 3. It is clear that the pH values of the majority of the studied water brands are located on the alkaline scale. Data obtained revealed that the pH level in AlQurayyat Poultry Farms which is the only licensed farm was 7.2. The minimum and maximum pH values were 6.48 and 9.63, respectively. The total dissolved solids (TDS) values varied greatly among water samples utilized for vegetable irrigation as well as those employed in the poultry production and sheep farming. Concerning the vegetable cultivation, TDS ranged between 1600 mg/L and 7008 mg/L. Regarding the poultry production, TDS recorded a minimum value of 115 mg/L and a maximum value of 4080 mg/L. These findings indicate that the drinking water in some farms is invalid. Out of 13 examined water samples, 4 samples were contaminated with bacteria.

Total chlorine in the water samples was obviously low. Chlorine level employed in the licensed chicken-indoor husbandry farm was non chlorinated. Total chlorine in the remainder of the water brands varied between 0.04 and 0.43 mg/L. Turbidity levels were relatively high and varied clearly among the studied water samples. Turbidity levels ranged between 0.17 and 8.7 NTU colour units. The level of sulphate salts showed marked variability among the studied water types. Five out of 7 water samples used in vegetable irrigation attained sulphate level more than 150 mg/L. The same level was recorded in one third of the water samples used for drinking in poultry and sheep farms. However, water sample collected from AlQurayyat Poultry Farm was 11 mg/L.

The level of phosphate salts varied markedly among the studied water types. The maximum value was 9.38 mg/L recorded for sheep farm, while the minimum value was 1.24 mg/L recorded for a poultry farm. Iron gradient of the drinking and irrigation water brands ranged between 0.05 and 0.12 mg/L. Nitrates showed marked variability among studied water samples. Except for a markedly low nitrate level (0.09 mg/L) recorded for AlQurayyat Poultry Farm, all the water brands in the present investigation were relatively high (Tables 1, 2 and 3). The maximum nitrate level was recorded for irrigation water (24.1 mg/L). Data obtained revealed that nitrite levels of the studied water samples were safe. Only one water brand used for drinking in sheep farms exhibited a relatively moderate value (0.354 mg/L) (Table 3).

DISCUSSION

The Saudi population experienced remarkable economic and social changes that are reflected in the food consumption habits, showing a preference for beef and chicken meat over lamb, goat and camel meat (Al-Balawi, 2014). The poultry industry in Saudi Arabia focuses on two highly nutritive products, namely table eggs and broiler meat. Freiji (2008) reported that a composite of complementary industries, for example breeding, cereal and oil plant production, processing of oil plants, mineral and vitamin production, production of vaccines, medication and disinfection facilities, grading and processing of table eggs have been developed. Poultry consumption rises sharply during Ramadan and Hajj seasons, where millions of pilgrims visit the country to perform their religious rituals.

The poultry industry in AlQurayyat showed no progress over the last 10 years. There are only two licensed broiler farms with a total production of 2500 chicken/day. Moreover, there are 30 unlicensed poultry farms accommodating a variety of domestic birds that are cohabitating with domestic rabbits in some occasions. AlQurayyat has no egg-producing poultry farms. The poultry production in AlQurayyat is insufficient, however this gap is currently filled by the products of some national poultry farms, for example Al-Watania, Astra, Al-Jouf and Fakieh or by the import market from Brazil and France. Saudi government in AlQurayyat must put a strategic goal to achieve self-sufficiency in poultry meat and egg production. To achieve this goal, a marked expansion of the productivity of the poultry industry and the implementation of a unified biosecurity system to reduce chicken broiler mortality rates that remain a major constraint to the expansion of broiler production (GAIN, 2014).

Unlicensed (illegal) poultry meat farms in AlQurayyat had only 5% production share in the poultry market of the city. Their production is mainly consumed by the owners of the farms as well as their families; only a small fraction of this production is displayed for sale in the market. Fortunately, the water quality of the licensed poultry farm in AlQurayyat complies with the specifications of the international agricultural organizations. However, water quality changes inside poultry house, due to either the warmer environment that facilitates the rapid replication of microorganisms or poor sanitation and maintenance practices, remain an ongoing challenge. Turbidimeter readings in the present study illustrated that the pH values were slightly acidic. It ranged between 6.8 and 6.87 in four unlicensed poultry farms. The pH level in AlQurayyat Poultry Farm which is the only licensed farm was 7.2. Hydrogen ion concentration (pH) below 5.0 has non-significant improvement in broiler performance. Elevated gradients of the organic acids such as citric acid can cause reductions in water and food intake decreasing the rate of growth. Because water has a natural buffering capacity and interacts with minerals, it is highly recommended to monitor the pH scale of the drinking water whenever using acidifiers.

Salinity is a problem commonly found in arid regions such as Al-Jouf Region. Runyan *et al*. (2010) suggested salinity level limits for different classes of livestock as follows: less than 1,000 mg/l, excellent for all classes of livestock and poultry; 1,000-2,999 mg/l, very satisfactory for all classes of livestock and poultry; 3,000-4,999 mg/l, satisfactory for livestock, but poor water for poultry. In poultry, watery droppings, increased mortality, and increased morbidity associated with poor growth may occur. Turkeys are particularly susceptible (Runyan *et al*., 2010). There was a considerable variability in water salinities around AlQurayyat. Regarding the vegetable cultivation, the total dissolved solids varied from 1600 to 7008

mg/L, indicating a profound challenge facing many crop farms in AlQurayyat. For the poultry production, TDS recorded a minimum value of 115 mg/L in licensed farms and a maximum value of 4080 mg/L in unlicensed farms.

The soil salinity increases in direct proportion to the salinity of irrigation water (Grattan, 2002; Hussain *et al*., 2010). The reduction in plant growth and crop's yield is mainly caused by the increase in osmotic potential of soil solution which takes place due to addition of excessive salts through irrigation water. This increase in osmotic potential reduces the availability of water to plants which results in stunted growth (Hussain *et al*., 2010). The plant extracts water from the soil by exerting an absorptive force greater than the force holding the water and soil together. The plant will suffer water stress if it is not able to extract sufficient water. As water salinity increases, greater care must be taken to leach salts out of the root zone in order to prevent their accumulation at levels which might reduce the yield. Alternatively, steps must be taken to plant crops highly tolerant to the expected root zone salinity. The frequency of leaching depends on the water quality and crop sensitivity to salinity.

To achieve efficient water management practices and to prevent many health hazards in the intensive chicken-indoor husbandry systems, the following guidelines/recommendations should be considered by the poultry raisers: (1) secure high quality drinking water, (2) minimize the bacterial and fungal load in the water source through regular sanitization, (3) gauge the efficacy of the water sanitization program by periodic analysis of the bacterial and fungal proliferation, (4) flush out the pipelines with a concentrated chlorine solution under pressure at regular intervals, (5) prevent leakages of water from waterier and pipelines inside the husbandry, (6) tightly cover the storage tanks to prevent contamination, (7) carefully clean the waterier and remove the old water every day, (8) choose and maintain an appropriate delivery system, (9) regularly monitor the functioning of automatic drinkers such as nipples, and (10) determine the rate of water consumption daily as an early warning sign of potential problems with flock.

The Saq aquifer is the precious gift of nature to Al−Jouf Region. The aquifer supplies the region with great quantities of clean water. The aquifer sustained the life in this amazing geographical area over the last decades. However, how long the groundwater resident in the Saq aquifer lasts remains questionable. Water used in several daily purposes could be injected to percolate (moving downward from the surface to the groundwater body). Injection may include ablution water from mosques, household water except for toilet water, wasted drinking water, wasted rainfall water and water used in street washing. Artificial recharge of the groundwater aquifers is a promising strategy to compensate, in part, for the overexploitation of the resident groundwater. John (2010) reported that the Disi aquifer is 320 km long and 500 m in depth. Vengosh *et al*. (2009) found that the Disi aquifer is polluted by radioactive radium-226 and radium-228 isotopes. Nick (2009) linked between radium isotopes and cancer of bone and Leukemia.

Water samples collected at specific time and place seem likely to represent the physicochemical and biological properties of the water source at a narrow spatio-temporal scale. Water sources are known to vary with time. As the earth's temperature continues to elevate, significant negative impacts on the freshwater supplies are expected as evaporation increases, resulting in droughts. The rate of evaporation depends on the temperature and relative humidity

that affects the amount of water available to replenish ground water aquifers. Konikow and Kendy (2005) suggested that more runoff and low infiltration rates combined with elevated evapotranspiration and increased irrigation is expected to lead to groundwater depletion.

It is the responsibility of the owners of the private groundwater wells to ensure that their water is safe from contaminants. Replacement of diesel engine-operated pumps by electrically-powered pumps is strongly recommended. However, it is the responsibility of the agriculture and animal wealth sector to establish an environmental research unit that can help ensure the abstraction of high-quality water from existing wells. Moreover, a water well system can help locate and construct alternative wells to replace contaminated, poorly constructed wells. The Ministry of Agriculture should follow the course of the projects related to sheep farming and provide all preventive, curative and guidance veterinary services in addition to the provision of vaccines and veterinary medicines. Supervision of the implementation of the periodic programs in the aim of maintaining the livestock in AlQurayyat is of great importance. To fulfill the growing demand for poultry and sheep meat of AlQurayyat (Al-Jouf Region) during the next 10 years, the agriculture and animal wealth sector, in cooperation with the private sector, is asked to establish a large scale poultry meat farm with a production rate of 100000 birds/day, a large scale poultry egg farm with a capacity of 200000 eggs/day and a large scale sheep farm with a capacity of 100000 members.

Future aspirations of the water sector in AlQurayyat should focus on smart groundwater mining, accurate evaluation of the extraction and replenishment rate, advanced hydrogeological studies and raising the awareness about the rationalization and wise usage of water within the community. Regular monitoring of the groundwater sources should be conducted by the authorities concerned in order to keep this vital source of potable water. A great care should be paid to the inspection of the heavy metals in the groundwater wells. According to UNESCO (2007), about 80% of all illnesses/deaths are attributed to water-borne diseases. Health problems related to heavy metal pollution cause the death of about 5 million people every year. Marcovecchio *et al*. (2007) mentioned that heavy metals in the groundwater aquifers originated from natural sources such as minerals eroded from rocks into sediment, volcanic discharges or anthropogenic sources such as domestic, industrial and agricultural effluents as well as ore deposits.

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Table (1). Physicochemical parameters of the water samples used for drinking in poultry husbandry at different localities of the study area.

Location	pH	TDS	Sulphate	Nitrate	Nitrite	Phosphate	Chloride	Turbidity
A	8.67	4080	> 150	4.4	0.018	5.3	0.04	3.6
B	7.2	115	11	0.09	0.007	1.24	0.00	0.17
C	7.6	2540	85	3.1	0.013	2.4	0.07	2.5

Table (2). Physicochemical parameters of the water samples used in crop cultivation at different localities of the study area.

Location	pH	TDS	Sulphate	Nitrate	Nitrite	Phosphate	Chloride	Turbidity
A	8.4	2120	145	2.7	0.009	1.89	0.09	0.94
B	9.63	7008	> 150	8.9	0.017	1.6	0.06	8.7
C	7.92	1600	134	3.5	0.015	5.18	0.09	0.65
D	7.79	5190	> 150	3.1	0.022	1.67	0.04	6.5
E	6.75	3410	> 150	8.4	0.012	2.1	0.14	1.1
F	6.88	2390	> 150	2.6	0.026	8.6	0.06	1.41
G	6.48	6340	> 150	24.1	0.039	3.97	0.23	3.5

Table (3). Physicochemical parameters of the water samples used for drinking in small scale sheep farming at different localities of the study area.

Location	pH	TDS	Sulphate	Nitrate	Nitrite	Phosphate	Chloride	Turbidity
A	6.81	2230	127	10.3	0.030	4.45	0.18	0.76
B	6.87	3660	> 150	12.2	0.354	9.38	0.43	6.76
C	6.88	2630	113	11.2	0.060	4.21	0..19	2.3

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Fig. (1). A private, illegal well tube irrigating a small land cultivated with palm and olive trees in AlQurayyat.

Fig. (2). A large temporary storage concrete reservoir assisting a ground water well in AlQurayyat.

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Fig. (3). Coriander field, one of the common vegetables cultivated in AlQurayyat.

Fig. (4). Salinization of the soil is a common feature in AlQurayyat.

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Fig. (5). A herd of sheep depending primarily on the Saq Aquifer in drinking and washing.

Fig. (6). An intensive indoor poultry production in AlQurayyat.