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Use of carbon in increasing the quality of drinking water - Case study: the wells of Savejbolagh villages

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Abstract

The drinking water of Jangale Dar village, environ of Savejbolagh city of Alborz province, is provided from a well located at this village. The water of this well is appropriate and within standard range in terms of qualitative factors, but the quality of the water becomes inappropriate in terms of turbidity, color, taste and smell due to the creation of bad taste and smell, especially in some days a year (mainly in spring and formation of runoffs); so that the consumers are not satisfied with this water. In this study, the effect of active carbon, as an actual absorbent, on the elimination of turbidity, color, taste and smell has been investigated in order to improve the quality of drinking water. The results of the study indicated that active carbon, as a strong absorbent with high porosities and broad lateral surface, are effective to eliminate turbidity, color, and smell. It was also observed that, the elimination percentage of turbidity, color, and smell on the beds with 30cm combination of sand and active carbon on 10cm fine sands is more than the beds with 35cm combination of sand and active carbon on 5cm fine sand). After investigating the elimination of turbidity, color, taste and smell in drinking water of Jangale Dar by absorbent on the bed with 35cm combination of sand and active carbon on 5cm fine sand within 3.5 minutes retention time, 63%, 85%, and 75% respectively were obtained, and the bed with 35cm combination of sand and active carbon on 5cm fine sand, in which the output water of prior bed was entered, within 7 minutes retention time, 82%, 100% and 100% respectively were obtained. After investigating the elimination of turbidity, color, taste and smell in drinking water of Jangale Dar by absorbent on the bed with 30cm combination of sand and active carbon on 10cm fine sand within 4 minutes retention time, 75%, 90%, and 85% respectively were obtained, and the bed with 30cm combination of sand and active carbon on 10cm fine sand, in which the output water of prior bed was entered, within 8 minutes retention time, 94%, 100% and 100% respectively were obtained.

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Introduction

Water is a component of the environment, that its quality is influenced by the health of environment. On the other side, improving environmental health is also directly related to the quality and quantity of water. A healthy water resource must be able to supply safe and sufficient water for the society. For this purpose, the resources have to be under monitoring and control of health responsible regularly; so that by being aware of the presence of any potential contaminants in water, control measures should be applied. Provision of safe water and proper management of wastewaters play the major role in reducing water-related infectious diseases. A set of measures on improving the environment and the health, safe and adequate water supply can reduce 40 to 100% of water related communicable diseases.

Seemingly healthy and clear water may contain a variety of pathogenic live microorganisms and therefore we must ensure the health of water before drinking (Bansal, 1988).

Supplying healthy and sufficient water in war zones and emergency situations is also very important; in this regard, proper selection of water resources and making necessary plans to protect water resources and distribution network as well as conducting refinery ways and disinfection methods on water as required process of refinement are among the measures of effective prevention of transferring diseases related to the water and providing the conditions for eliminating possible pathogenic factors. In fact, supplying water with less than 1 NTU turbidity and at least 0.05mg free remained chlorine for drinking and sanitary uses are effective factors on the health of people in every situation (Bansal, 1988).

Problem statement

In recent years, the crisis and lack of drinking water resources and vital need for supplying it have required the situations to step into providing high quality drinking water with national and global standards by using a simple and economic method.

Given that there are several methods for reaching to global and national standards in water refinery, it worth note that this study attempts to find and optimize one of these methods. A method should include the following features (Crittenden and Weber, 1978):

1. Less implementation costs and economically justifiable.

2. Regarding to the principle of integrity and independence of the homeland, create the least dependence to the foreign countries

3. Practical and executable and also consistent with the existing technologies

4. Consistent with the experience of user forces existed in the country

According to the methods of water refinery in small communities, such as Electro-dialysis and reversed Osmosis, which require high maintenance and exploitation cost. The present article has tried to increase the quality of drinking water in the village by using active carbon which is economic and needs simple human exploitation. Referring to the method of water treatment in medical records since ancient times indicate that there is direct correlation between the cleanliness of water and human health. Socrates, the father of Medicine, says that: “whoever wants to make research on Medicine appropriately, first should examine the water consumed by the people; since water is very important in the human health.” Historical sources show that, from two thousand years BCE, water treatment has been used for drinking water. Chinese simmered the water for treatment. In Sanskrit (ancient language of Indian) and ancient Greek, belonged to 1333 years BCE, water treatment methods have been

explained. The people of that time knew that heating water can make it purified. Well as granules of sand filters were used for water treatment. Images on the wall of Tomb of Ramses II indicate that, 2533 BCE Egyptians used Coagulation (a chemical method in which the suspensions get bigger by adding different chemicals to water, so that they are deposited) method for water treatment. They separated many of minerals through deposition by adding Aluminum Sulfate. The Egyptians also separated the suspensions in water by using wick siphons transferring water from one bowl to another. This operation has been also shown in the paintings of Egyptians belonged to 29 centuries BCE. To investigate the quality of water, physical and appearance quality, chemical quality, and Bacteriological quality of water is under consideration. Physical quality of water refers to the features, including color, turbidity, taste, and temperature which are distinguishable by sight, taste, touch, and olfactory senses. In any event, the willingness of consumer for using water with such characteristics, however, will be decreases by the increased in proportion to the color, smell, turbidity, taste and ..., because consumers will recognize them easily with their senses. Turbidity is a good index to show the quality of consumption water, it also indicates the progress of water treatment. The lower is this index, the quality will be better even in less than 1 NFT. If we could supply such water for the society, then we have provided a good quality of water (Clifford, 1983).

Drinking water should be odorless and its taste should be delicious. The taste of water is, however, due to the various minerals of chloride, salts of magnesium, iron and Aluminum. EC and PH of the water are among physicochemical properties of water represent the total solids of solution and water acidity, respectively.

Treated water or water resource prepared for consumption doesn't contain usually physical contaminators, but they might be subjected to physical contaminations during the time stored in reservoirs for consumption; such that the openness of reservoirs and the radiation of sunlight into the tanks, as well as the entrance of algae and aquatic plants from the environment into the water storage, conditions for growth and proliferation of algae will be provided with photosynthesis. After a while, a layer of different algae may be grown at the wall of water reservoir and resulted in unwilling taste, smell, and color (Femogarica and Utrina, 1988).

Given that use of such tanks for water storage is extensive in military and war regions, especially operational areas, fully close of tanks will be helpful; because it both prevents from entering particulate air into water and also inhibits the growth conditions for algae. Therefore, physical quality of water is also protected and the problems associated with washing and removing the algae of tanks by safe and healthy water will be overcome. Chemical quality of water is related to the presence of hardness ions and particularly Cations and Anions soluble in water, and also pesticides and organic compounds as well as toxic and scarce elements; for which certain and standard amounts have been specified. One of the most important and frequent of them is hardness ions in the water, to which the human body is not much sensitive and consumes waters with the hardness of 350mg per liter easily. The body can also consume the hardness of 500mg per liter for a short time. While very light waters are not tasteful for drinking, it is recommended for the hardness of water to be higher than 50mg per liter. Hardness related cations and anions, respectively, are cations of magnesium, calcium, strontium, iron, aluminum, manganese, copper and the anions of carbonate, bicarbonate, chloride, sulfate, nitrate and silicate which are water soluble. Among the chemicals found in water and threaten human health are pesticides and organic compounds that may be entered to the water resources through sprayed underlying water drainage, the arrival of domestic and industrial wastewaters, or through an

destroying operation. Toxic and trace elements are included in the chemical composition of water which have negligible quantities in water. Where, we have to use prepared water bottles for supplying water for military, controlling all of the trace elements are important and the essential; among the elements that are present in these waters shall be examined as follows:

Beryllium, cadmium, chromium, copper, iron, manganese, magnesium, mercury, nickel, selenium, strontium, vanadium, zinc, fluorine, iodine and Bromine. Including the possible presence of toxic elements in water resources due to incomplete or inadequate treatment of wastewater discharged into receiving waters are Arsenic, cyanide, lead, mercury and cadmium. Military forces, especially those positioned in tropical areas, usually have high water consumption; if these forces are in operation or training activities in tropical areas, they will lose high amount of water in their body through sweat, and it is necessary for them to increase their drinking water; so that thermal damages will be prevented by replacing lost water. It should also be noted that, high consumption of drinking water can also resulted in severe venation and come to the death of lost Sodium through sweat; because the water consumed cannot provide lost minerals lonely due to the chemical quality and several death have been reported so far because of venation of high consumption of water and reduced Sodium in the blood of athletes and military forces (Hassler, 1974).

Lack of awareness and inappropriate interpretation of symptoms, when person suffers from lack of water and thermal damage, can leads to provision and substitution of water without providing salt or sodium and cause him to death. While, by predicting sufficient use of salt pills, this problem can be resolved easily. We usually face with the problems induced by chemical quality in the water resources used for drinking and sanitary even in military centers and regions. Water minerals are often at acceptable level, but undertaking necessary controls for ensuring chemical quality in each situation (Hassler, 1963).

Bacteriological quality

To examine the health of water, measuring Bacteriological quality is of certain importance; such that when we talk about water health, most of diseases transferred by different microorganisms are recalled. A healthy and clear water may be contaminated with a variety of live pathogenic microorganisms why in each situation it is necessary to ensure the health of water and the absence of microorganisms before taking consumption; because the presence of biologic contaminators especially pathogenic micro organisms in the water can cause epidemics and spread of different diseases and lead to irreparable damages. The symptom of an epidemic which is transferable through water is the spread on entire society and among all age and gender groups in companion with Dysentery, Gastroenteritis and abdominal cramps (Hassler, 1974).

When you study a disease transmitted through contaminated food or water, collection of information such as causes, laboratory findings, mode of transmission, prevalence, history, the average duration of treatment, duration of disease, age and sex distribution of deaths mortality, re- attacks, final diagnosis of physicians are essential for prevention and control. Many of these epidemic diseases are frequent by sudden increase of microbial contamination in water distribution network; so that several cases have been reported throughout the world. While, by continues monitoring and control of Bacteriological quality, the incidence will be prevented. Especially in war and military zones, such controls may be of great importance where can be threaten by the enemy. Many of health problems in the developing countries are the lack of safe drinking water. Since the core of sustainable development is healthy human, and human health depends on the enjoyment of desired drinking water,

there is nowhere for positive health and social welfare without providing clean water. Water is important from two health and economic dimensions. From economic view, it is the driver of industry wheels and promotion of agricultural activities. From health viewpoint, high quality water guarantees human health. Water, with its appearance and content extensiveness is another live world. Although it is hidden from our sight, but the water has a huge impact on the lives of animals, especially humans. In addition to supply needed liquid by the body to its absolute sense, i.e. H_2O, drinking water contains minerals and trace elements essential to living organisms and human. The lack of them in the water affects living things, and can lead to the occurrence of some diseases (Hutton and Cheremision, 1978).

Lack of Iodine and Fluorine and their relationship to endemic goiter and tooth decay expresses the importance. In addition to the chemicals, diversity of microorganisms found in water that some of which are pathogenic and cause dangerous infectious disease. Water sanitation is directly related to the reduction of infectious disease. So that, death rate from cholera after drinking water supply decreased by 74.1 %, the death rate from typhoid 63.3%, the rate of death from dysentery 23.1%, the death rate from diarrheal 42.7%. So, planning and expenditures to provide safe water can be a noticeable investment for your future. Supply safe drinking water to the community is one of the most effective and sustainable technologies to improve health (Hutchison, 1990 ; Sontheimer and Crittenden, 1988).

Available water resources and prioritization of selection

Accurate identification and selection of water resources have important role to mitigate problems and diseases are water related. A healthier quality water which is possible to supply with lower costs for the consumers are preferred than other water sources. However, close examination of the circumstances under which we have been considering the quantity and quality of water and the cost per liter of water is essential. Prioritization of different types of water sources is as follows (Mckinny, 2004):

1- The first priority is groundwater resources that are less infected by passing through the lowest layers of the earth. They often get the best quality for drinking by disinfection process (chlorination). Groundwater resources include water fountains, aqueducts and wells. And these resources may be available to many of military centers; where sanitation measures are required for optimum use of the wells, aqueducts and fountains.

Among the most important measures for the sanitation of wells and aqueducts and fountains include:

– Health investigation of the around of water resource and to ensure the absence of contamination of the water source upstream.

– Creating concrete wellhead platform and creating streams around drains to prevent water from entering surface water and redirect it to other routes.

– Close the wells' door and water outlet casing as well as using pipe to direct water from aqueducts and fountains out, so that others, both humans and animals, cannot access into the wells, canals and springs.

– Prevention of sunlight into the water fountain and railings around the fountain and classification panel of Qanat to within 50 meters to prevent the animals from access and also predict a particular place for animal water fountains.

– Chlorination before using water

2- The second priority is the selection of available water resources, surficial waters of rivers and

freshwater lakes, which are required to be disinfected in addition to conventional purification including flocculation, rapid mixing, sedimentation and filtration; it needs more costs than the first priority.

3- The third priority is the use of salty water resources in the absence of surface and ground water. In this case, the cost of water supply is very high.

However, in some cases, you might be forced to use rainwater for supplying drinking water due to the necessity and lack of appropriate water resource. In such regions usually rain water are collected in cisterns, and their water are mainly contaminated and undrinkable. It is necessary to purify the water in such situations and remove any kind of suspensions and finally drink it after boiling and disinfecting.

Regarding to the consumption per capita of 20 liters for drinking and food preparation, the needed drinking water for each person in the drought can be supplied as packaged bottles filled in a certified plant. And also use the existing water of the region with good physical and microbial quality for sanitary uses. In fact, using two separated systems will be necessary if they are justifiable economically and consistent with the situations. For military forces located in a base, at least 60 to 80 liter water per year is essential for drinking and sanitary uses.

4- Another priority that we would be enforced to use it in some cases is to melt the ices for supplying needed water. In this case, the water melted from ices must be boiled at first and be used after disinfection (Nawwar, 1989).

Active carbon

Active carbon which used in water treatment process is made up by the heat treatment on the materials with carbon basis and there are millions of pore, cleft, and microscopic tiny cavity on their surface. If we look at the surface of active carbon with a microscope, we will see a pumice stone. The pores on the surface of active carbon cause to contact area carbon filter with water increases. So that one pound of active Carbon will provide a level equivalent to 60 to 150 acres. The microscopic pores will act as a trap for large organic molecules and small organic molecules will also absorb on the surface of carbon. The ability of active carbon for the removal of certain micro- organisms and organic chemicals , especially pesticides, and trihalomethanes (THMs) , which are by products of chlorine , trichloroethylene (TCE) and PCB depends on many factors including the type and amount of carbon used, filters designing , water flow rate , duration of filter using and type of impurities in water (Sarai, 2006).

Carbon filter types in water purification device

In general, two types of carbonic filter are very common in home water treatment devices: gravel Active Carbon (GAC) and the carbon block or blocks of carbon. Gravel Active carbon filters have been made by carbon sand grains and they have adsorption properties and carbon block filters in carbon block (solid piece of carbon) created and can be eliminate somewhat of suspended particles in the water (Sarai, 2006).

The amount of adsorption of carbon filters in water purification device

Carbon adsorption process is controlled by the microscopic pore diameter existed on carbon surface and the amount of organic molecules escape from these pores. Adsorption rate is the function of molecular weight and molecular size of the organic matter. Granular activated, carbon effectively remove residual chlorine in drinking water and protect other components of domestic water treatment systems such as reverse osmosis membrane filter which is sensitive to chlorine. Carbon filters are lonely insufficient for water treatment, and often are used in combination with other filters. How to use carbon filters along with other filters

is very important note for designing a standard and quality water filtration system (Simsek, 1970).

The difference between healthy and non-healthy carbon filters

All the models of Aqua Joy domestic water treatment have carbon filters. Active carbon filters are used at the first, third and fifth stages of domestic water purification as well as for pre-filtration systems for the whole house water, shower filter, and other products. Unlike non-standard and non-healthy water purification systems using coal in their carbon filters without considering the health of consumers, Aqua Joy carbon filters are made of coconut and have got herbal origin, which are free of any harmful impurities, such as heavy metals and they are suitable for sanitary and food uses (Smethurst, 1979 ; Weber, 1970).

Materials and methods

Raw water quality testing has been performed by laboratory devices, titration and numerical calculation methods (Snoeyink, 1978):

1- To calculate the number of sodium and potassium, FLAME PHOTOMETER has been used.

2- To calculate the pH value and temperature of the sample in the laboratory, WTW PH 330 I has been used.

3- To determine the electrical conductivity number, HACH SENSION 5 has been used.

4- To determine the number of Turbidity, 1233 P HACH TURBIDIMETER has been used.

5- To determine the number of nitrate and nitrite, SPECTEROPHOTOMETER

6- model JENWAY6305 UV / ns has been used.

7- To obtain the number of total hardness and calcium hardness, titrated sample with EDTA has been used.

8- Normal / to get the total alkalinity, titrated sample with sulfuric acid 31 has been used.

9- The remaining numbers including magnesium hardness and permanent hardness has been obtained by computational methods and formulas.

Table 1. Raw water quality testing results in Jangale Dar village are as follows

Suggested test method	Amount in sample		Anions	
	Meq /lit	Mg /lit		
Fluoride Electrode/SPADNS	-	0.1	fluoride	F
Argentometry	-	16	Chlorine	Cl
Turbidimetry	-	78	sulfate	So4
Calculation	-	0	carbonate	CO3
Calculation	-	293	bicarbonate	HCO
Vandomolibdop	-	0	phosphate	PO4
Spectrophotometry	-	0	nitrite	NO2-
UV Spectrophotometry	-	5	nitrate	NO3-

Suggested test method	Amount in sample		Cations	
	Meq /lit	Mg /lit		
Calculation	-	85	Ca	Calcium
Calculation	-	19	Mg	Magnesium
Flame photometry	-	13	Na	Sodium
Flame photometry	-	8.0	K	Potassium
Phenanthroline method	-	-	Fe	Iron
Phenanthroline	-	-	Mn	Manganese

Appearance and Performance Factors	unit	Amount in sample	Suggested test method
Temperature in laboratory	c	25	
EC	Moh/Cm	920	Conductivity meter
Torbodity	NTU	3.86	Nephelometry
Color	PtCo	20	Visual/colorimetry
Total solid of solution	Mg/lit	644	
Total hardness	Mg/lit	293	EDTA titration
Persistent hardness	Mg/lit	53	EDTA titration
Alkalinity	Mg/lit	-	Acid titration
Alkalinity	Mg/lit	-	Acid titration
PH		7.31	Wide range PH meter
Total quality	Mg/lit	240	Acid titration

Other	Unit	Amount in sample	Suggested test method
Total anions	Mg/lit	6.951	
Total cations	Mg/lit	418.6	

Comparison of the results with the standards

Because of the excavation type (handmade), high water level and proximity to a valley, in which runoff is occurred during rainfall seasons, the water of this well is with the taste, color and opacity exceeds the standard in some months of the year.

Therefore, using active carbon has been investigated in the reduction of these 9 parameters, and the results of sample analysis and elimination yield are shown below.

Substrate	3.86 NTU Remove percentage	20 TCU Remove percentage	4 TON Remove percentage	Crude samples number time (min)
35 cm mixed sand and active carbon on 5 cm sandy	1.42 63%	3 85%	1 75%	3.5
35 cm mixed sand and active carbon on 5 cm sandy	0.70 82%	0 100%	0 100%	7
30 cm mixed sand and active carbon on 10 cm sandy	0.96 75%	2 90%	0.5 85%	4
30 cm mixed sand and active carbon on 10 cm sandy	0.23 94%	0 100%	0 100%	8

As it can be observed in the table of Testing quality of raw water, removal rate in the down beds (93 cm combination of sand and activated carbon on 23 cm of fine sand) is more than above beds (95 cm combination of sand and activated carbon on 5 cm fine sand).

Conclusions

In general, we can say that drinking water exited from the village's well has got acceptable quality, but the major problem about the well can be the sudden increase of some parameters including turbidity and color; which is the main factor of dissatisfaction in rainfall seasons and formation of runoffs. On the use of water treatment methods, as it was implied, the most efficient and convenient method for Jangale Dar village is using active carbon filter with sand bed. But, all water treatment methods cover the contamination removal somehow. It is while we can perform prevention with much lower costs, and undertake appropriate measures before the imbalance of water quality due to the precipitation. In the upstream of the well, there are many residential villas that provide appropriate bed for the rinse of rain and formation of runoffs by producing trashes and leaving them in the upstream. Beside this well, there is small valley that wash all trash accumulated within several months by the rain and direct them on the river, so that a part of contamination will be entered to the well.

The most appropriate and the best way to protect this well is to determine well privacy, improvement of well outlet, and creating channel for collecting surficial runoffs. By these measures, there would be no problem and sudden change in terms of qualitative parameters. Examining the test results about the impact of adsorption columns on water samples, the following conclusions are presented:

1- Mixed bed of sand and active carbon is effective as a sorbent for the removal of turbidity, color, taste and smell.

2- Removal efficiencies by the lower bed (30 cm mixture of active carbon and sand on 10 cm of fine sand) are more compared to above beds (35 cm mixture of active carbon and sand on 5 cm fine sand).

3- Less consumption of active carbon can be economic by the increase of sand-bed in addition to increasing the economic efficiency

4- The effect of active carbon on the removal of colors with low height column is more than 2 other parameters (taste, smell, and turbidity

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