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Water quality in southwest rural areas of Morocco

– A field- study

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Abstract

Former studies of water quality in southwest Morocco shows that some water sources in the rural region of Agadir are affected by intrusion bringing chemical values above normal in drinking water of the villagers. In this study, I want to investigate if the intrusion also creates increasing exposure of microorganisms and water borne diseases among the villagers. In a field- study, face to face interviews following a questionnaire were used to gather socioeconomic, clinical and water use information about the subjects living in the study area. Water sampling was made in 10 rural areas around Agadir. PH, conductivity and temperature were measured directly at the water locations. These parameters were re-measured at the chemical laboratory of Ibn Zohr University using traditional analytical methods. Additional chemical analysis (Bicarbonate, Calcium, Magnesium, Potassium, Sodium, Sulfate, Nitrate, and Chlorine) were also made at the university. The bacterial analysis (microorganisms at 22 ºC and 37 ºC, Coliform bacteria, *Echerichia coli*, *Intestinal enterococci* and *Clostridium perfingens*) was made with the same water sampling approach as the chemical analysis adding 1 random urban district for comparison. Water samples for bacterial analysis were analyzed within 24 hours at Veto lab using ISO methods according to NM 7899-2, 6461-2, 9308-1, and 6222. The results show that all rural water samples according to the guidelines for drinking water are classified as non- drinkable and the urban water sample is classified as drinkable. The rural respondents state that they do not collect their drinking water from the sample sources but this does not exclude increased exposure to contaminated water and the increased risk of getting infected by microorganisms through the use of contaminated sources for bathing, washing, swimming, cleaning, and cleaning feeding utensils. My conclusion is that further investigation must be made on different sources of contamination and existing factors that generates the growth of microorganisms in the rural wells along with recommendations for policy makers, surveillance managers, clinicians and laboratory staff to prevent any potential waterborne outbreaks among rural villagers in southwest Morocco.

Introduction

Microbiological research in Moroccan southwest rural areas is rare. However, the few earlier studies of water quality in Imsouane- and Tildi village shows that some water sources in the rural region of Agadir are affected by intrusion of sea water, manure and sewage bringing chemical values above normal in drinking water of the villagers. In this study, I want to investigate if these intrusions also create increasing exposure of microorganisms and water borne diseases among the villagers.

The capacity of water to transport toxic agents and other unhealthy substances has a significant impact on our drinking water. Both microbiological and chemical impurities reach us through drinking water. Microbiological infection is often characterized by short incubation time and acute illness such as gastroenteritis (diarrhea and vomiting), nausea, and fever. In poor countries with low sanitary conditions and insufficient healthcare, the outcome can be severe. On the other hand, the effect of chemical impurities often does not show until several years later. The long incubation time makes it difficult to connect cause and effect. Exposure to toxic chemical substances can in some cases have serious consequences such as cancer. Despite long incubation time, the health effects of chemical pollutants are smaller in comparison with the ones caused by microbiological infections. Drinking water supply is vulnerable because of the diverse contamination possibilities in the water production. The most obvious indication that preparation and distribution of drinking water is appropriate is the health of the consumers. A good knowledge about the number of outbreaks and incidence of waterborne infections is therefore an important basis of judgment of where the lack exists and how to combat it (Dryselius 2012). Diarrhea occurs frequently in developing countries in conditions with poor sanitation and hygiene, inadequate water supply, poverty and limited education. Over the last century, many countries experienced economic growth and overall environmental conditions improved dramatically, which in turn decreased the burden of diarrheal diseases in developed countries (Nelson and Williams 2014). As middle-income and developing countries continue to undergo similar economic, social, and epidemiological transitions, it is likely that the burden of diarrheal disease will continue to decline. The use of contaminated sources of water for bathing, washing, swimming, cleaning, and cleaning feeding utensils have been implicated in transmission, as well as consumption of contaminated water. In developing country settings without access to tap water in homes, poor handling practices of water stored in houses- mainly involving introduction of contaminated hands or utensils into water containers- have been linked to an increased risk for diarrheal diseases (Nelson and Masters Williams 2014). Studies have now documented that water quantity is more important than water quality in determining risk of diarrheal disease, which highlights the importance of access to a source of water within a short distance from home. This factor arises because water availability is important for hygienic behaviors that would prevent much of the transmission by person to person or through food (Nelson and Williams 2014).

The coming of the first rains in months can cause animal and human feces on the ground to wash into wells. Alternatively, the dry season can close wells and concentrate microbial life of all kinds in the remaining wells. During the WHO's decade of water development in the 1980s, water -related diseases were classified into three development -related categories that continue to be useful: water -borne diseases, which are ingested; water -washed diseases, which are preventable by hand / hair / clothes / floor washing and other hygiene, and water -based diseases, which are vectored diseases requiring water for the vector to breed (Meade and Emch 2010).

In Morocco, water supply and sanitation is provided by private companies in the largest cities and public municipal utilities in 13 other cities and by a national electricity and water company named ONEE. ONEE is in charge of bulk water supply and water distribution in approximately 500 small towns. In 60 of these towns, ONEE is also in charge of sewerage and wastewater treatment. Since only 13% of collected wastewater is being treated and lack of house connections in the poorest urban neighborhoods exists and furthermore limited sustainability and functioning of rural systems, there are several remaining challenges in Morocco. A national sanitation program was established in 2005 with the aim of treating 60% of collected wastewater and connecting 80% of urban households to sewers by the year of 2020. In the Souss -Massa part of the country where this study was conducted, the groundwater resources are overexploited. In this area irrigation is the predominant water use. Given that only 13% of the collected wastewater undergoes any treatment, there is limited planned reuse of reclaimed water in Morocco where former wastewater or sewage is treated to remove impurities and solids. This is then used in sustainable landscaping irrigation where groundwater aquifers are being recharged. This is done to meet commercial and industrial water needs, and for drinking. The national water office

ONEP is responsible for sanitation in small and medium-sized towns. The operation of wastewater treatment plants in larger cities is done by only a few municipal utilities. In 2011, 82% of the Moroccan population had access to an improved water source by access to piped water in their house or in the yard of their house (59 %), a public stand pipe (11%), a protected well (5,6%), collected water from springs (7%) where half of these springs (3,5% of the population) were estimated to be protected (The World bank 2014). Of Moroccans essentially living in rural areas, 1,5 % relied on rainwater harvesting as their main water source. These different sources are classified as improved water sources by the WHO. Out of the 18% of the population who did not have access to an improved water source some used water from tankers as their main water source (1%), some collected water from unprotected public wells (7%) and from unprotected private wells inside their home or yard (4%), some took their water directly from rivers and open reservoirs (2,5%) and another 3,5% were estimated to use an unprotected spring as their main source of water supply (The World bank 2014). In 2011, 83% of the urban population and 52% of the rural population had access to improved sanitation. The poorest are the ones who have no access to sanitation as a 2004 World Bank study noted: "Sewerage service is completely lacking in the peri-urban areas of secondary urban centers. Slums scattered across the bigger metropolitan areas are also deprived of access to the sewerage collection network, reinforcing the health risks and poverty stigma in those neighborhoods".

Research objective

The research objective in this study is to investigate if the intrusion in the study area also creates increasing number of microorganisms and how this will affect the water quality of the villagers.

Hypothesis

Villagers in rural areas in southwest part of Morocco get exposed to contaminated water which could increase the risk of waterborne infections.

Research methodology and methods

Interview

Face to face interviews following a questionnaire were used to gather socioeconomic-, clinical-, water use-, and hygienic information from the subjects living in the city of Agadir and in nearby rural areas. It also collected the opinions and values of the subjects regarding their drinking water quality (Link to the questionnaire: https://docs.google.com/forms/d/1uBWmLxq9JdZ9EIYg0zwN0gAth3OY8W3ddQzgFwbvykQ/viewform?usp=mail_form_link). The interviews were performed between 30th april and 12th may 2014 in the urban area of Agadir (L'erac, Lezamican, Batwar, Dakhla, ElMassira, La ville nouvelle, Bensergaou, and Essalam), and the surrounding rural areas of the city (Ash'Touka and Sidi Abou Jalal). The purpose of using interviews in this study was to discover associations between the situation of the study population and the risk of getting infections from their drinking water. The original purpose was also to make a comparison between the urban and rural subjects. However, the time limit of the fieldwork didn't allow for such a comparison as the rural respondents were far fewer than the urban. Still, collected data from the interviews will be presented in the results section as a tool to view some common factors among the subjects which can be traced to increased exposure of or vulnerability to waterborne infections.

To ensure that the collected data is meaningful, the questionnaire was tested on suitable subjects in Sweden to identify potential problems with the survey. Simple, short and specific questions were used in both open- ended and closed questions. Every interview began with a short explanation, a background to the study, and the relevance of the questionnaire to the fieldwork. The interviews were made in the respondents´ native language, Moroccan- Arabic (Darija). A total of 16 urban and 2 rural interviews were gathered during the fieldwork.

Chemical analysis

To assess the quality of water sources in the study area, water sampling was performed in rural areas close to the city of Agadir. Water bottles of 500 mL each were washed several times and then filled with water from 9 wells and 1 spring. Water samples were tested at site with real time instruments from "Lab Quest 2 Environmental package" containing pH sensor, conductivity probe and stainless steel temperature probe. The measurements were registered directly at the water locations with double documentation. All parameters together with additional chemical analysis (Bicarbonate, Calcium, Magnesium, Potassium, Sodium, Sulfate, Nitrate, and Chlorine) were then confirmed and re measured at the chemical laboratory of Ibn Zohr University.

Bacterial analysis

Analyses of indicator organisms circumvents many of the problems that are associated with direct pathogen analyses because they are generally cheaper, easier, faster, standardized and often leads to quantifiable results. The limitation is that instead of directly detecting a microbiological risk, it only indicates a possible risk. Depending on which way these indicator microorganisms imply possible risks, they can be divided in to three partially overlapping types:
1. *General microbiological indicators*. Indicates the efficiency in a certain manufacture process or general conditions for microbiological growth.
2. *Fecal indicator*. Implies presence of fecal contamination.
3. *Index- and model organisms*. Implies more directly the risk of occurrence of specific pathogens because of qualities that resembles these.
An example of general microbiological indicators are cultivable microorganisms at 22 °C. The parameter is considered suitable to assess if manufacture and disinfection of raw water is working appropriate and can therefore be seen as an indicator of risk that other microorganisms (among them pathogens) is passing through the manufacture. For indication of fecal contamination there are several organisms that in various degrees implies that this is the case. The parameter coliform bacteria is a fecal indicator, a highly heterogeneous group whereas only certain organisms occur in animal and human feces. *E. coli*, however, is highly and better suitable for indication of fecal impact and is, because of its partially limited survival time in the

environment, useful for indication of newer fecal contamination. *E. coli* is of course a very fitting index- and model organism for pathogen *E coli* strains and other bacteria as well such as *Salmonella* and *Campylobacter*. *Enterococci* is also a suitable parameter for indication of fecal contamination and also indicates, through its longer survival in the environment, older and even more long range fecal contamination. Also *Clostridium perfingens* can be used as indication of more remote fecal contamination in time and space and in addition this indicator has the ability to form spores that are extra long-lived and resistant against outer stress. This makes them the bacterial indicator that is the best suitable index organism for virus and parasites (Dryselius 2012).

The bacterial analysis were performed by taking water bottles of 500 mL each that were washed several times and filled with water from 9 wells and 1 spring in the rural region. The same approach was made during water sampling in the city of Agadir from tap water in a household within L'erac district (1 in total for comparison). All samples were kept in cooled boxes during the transport and labeled with location and date. The samples were analyzed within 24 hours at "Veto lab"- specializing in microorganism detection in export and import products using ISO (International Organization for Standardization) 7899-2, 6461-2, 9308-1, and 6222.

Microorganisms at 37 °C and 22 °C

Enumeration of microorganisms viable for counting colonies at 37 ºC and 22 ºC was made according to NM ISO 6222. 1 milliliter of non- diluted water, 10^{-1} dilution, and 10^{-2} dilution were inoculated in Gélose YEA and left for incubation at 37 °C and 22 °C. After 44 hours (± 4 h) and 68 hours (± 4 hours) respectively the plates were analyzed by this formula: N= SumC/Vx (N1+0,1N2) x d, where N= the number of microorganisms per ml water in CFU (colony-forming unit), C= the sum of colonies counted on all the plates, V= inoculum volume applied on each plate, N1= number of plates restrained at the first dilution and N2= number of plates restrained at the second dilution. This analyses takes up to three days to complete (International organization for standardization 2010).

Coliform bacterias and Echerichia coli

Enumeration of coliformes and *E. coli* was made according to NM ISO 9308-1. The analyses started by filtrating the water using 0,45 µ -47 mm filter followed by incubation at 37 °C (± 2 °C) during 24 hours (± 2 hours) on Gélose lactose TTC and Tergitol. First counting was made after 24 hours. After 48 hours all the colonies surrounded by a yellow halo of lactose fermentation on the membrane was counted again. The plates containing between 20 and 80 colonies of coliformes were retained, this should not exceed more than 200 colonies in total. A representative number of yellow colonies were picked out (a minimum of 10) and inoculated in a tube containing tryptophane bouillon for incubation at 44 °C during 21 (± 3 hours) and further 37 °C during 24 hours. On the third day the confirmation was made by making an Oxydase test for each colony that was picked out from the TSA (tryptone soya agar) (Fricker et al. 2008).

Intestinal enterococci

Enumeration of *enterococcus* was made according to NM ISO 7899-2. Filtration was followed by incubation on Gelose SLANETZ in 36 °C (± 2 °C) for 44 hours (± 4 hours). Counting of the characteristic colonies was made after 24 hours and 48 hours. Curved, bricked, red, brown, and pink colony membranes (not exceeding 200 colonies in total) were then transferred to gélose BEA. Confirmation and counting was made after incubation in 44 °C during 2 hours. All the colonies that turns black in the BEA environment is defined as *enterococcus*. Counting is made in CFU per 100 ml water. The results is expressed as *Enterococcus*/ 100 ml= *Enterococcus* confirmed BEAx100/ filter volume (International organization for standardization 2010).

Clostridia perfingens

Analyses of *Clostridia*, search and enumeration of anaerobic sulfite reducer spores, was made according to NM ISO 6461-2. The method starts with water bath heating in 75 (±5) °C for 15 minutes. After filtration the membrane was removed with sterile forceps and placed with the top side facing down in the bottom of a petri plate, making sure that no air bubbles are trapped under the filter. After cooling to 50 °C, 18 ml of liquefied culture medium was carefully poured on the membrane. After the middle layer had solidified, anaerobic incubation was made at a temperature of 37 (±1) °C in the incubator for 20 (±4) hours and 44 (± 4) hours. The filter membrane was then placed on the agar with the surface facing upward. This was followed by further incubation at 37 (± 1) °C for 20 hours and 4 C° for 44 (± 4) hours. During day 2 all the black colonies were counted and the results were calculated in CFU per 100 ml water according to this formula: MASR spores/100 ml= the number counted * 100/ filter volume (International organization for standardization 2013).

Results and discussion

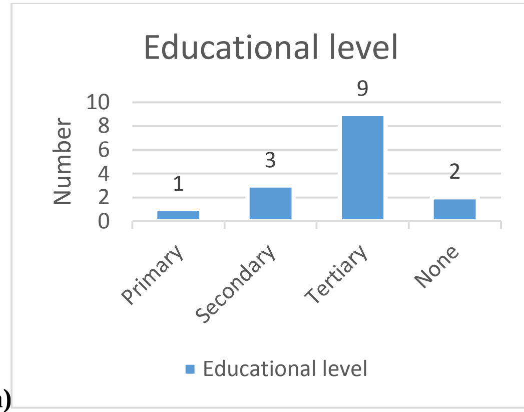
Interview

The interview responses were a total of 16 in the urban area and a total of 2 in the rural area. Because of the inequality of responses between the urban and rural subjects, only the urban results will be presented and discussed in this section as no significant comparison can be made. Still, the data collected from the 2 rural respondents will be mentioned in a brief and less detailed manner in conjunction with the urban interview results. This is made not to directly make assumptions of differences between the two regions, but rather to get a hint of were to discover and target possible factors that will make one group more exposed to water borne infections than the other.

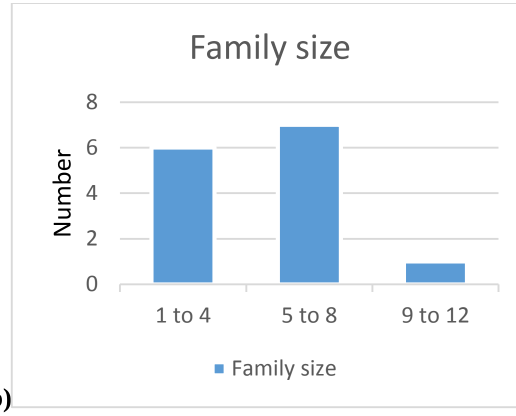
Respondents from the urban population were between 21-70 years old, and in the rural area 35 and 42 years old. Gender was equally distributed in the urban area, 8 females and 8 males and in the rural area 2 females.

Questionnaires that are administered as interviews have the advantage that the respondent can get unclear questions clarified. The open ended questions in the interview had the advantage to collect and identify a wide range of possible responses and also to give the subjects an opportunity to state their own views about a topic, but this also required a large amount of time for each interview while the closed questions were easier to code and quicker to complete (Williams 2003).

Urban socioeconomic information



a)



b)

Diagram 1. (a) The educational level and **(b)** family size of the respondents. The majority of the respondents living in the urban area are highly educated (academics) and live in medium sized families in spacious houses.

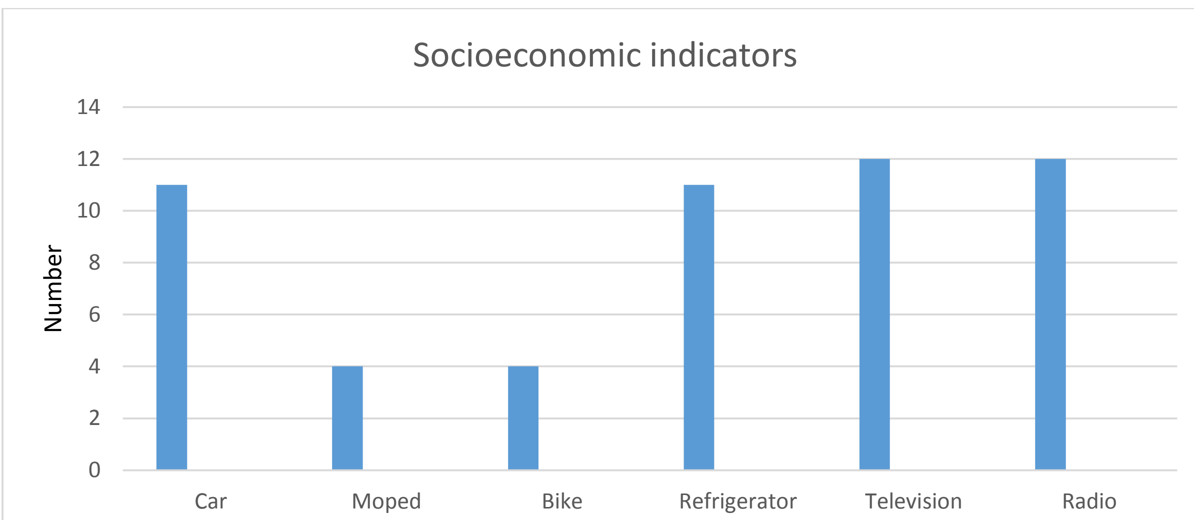


Diagram 2. Total number of socioeconomic indicators in households of all the respondents. The results show overall good living standards.

The purpose of investigating the socioeconomic situation of the respondents was to discover potential links between their economic standards and increased vulnerability for waterborne infections. The results from their social status and educational level show that the urban study population have the means to economically take care of themselves and their families as well as the ability to comprehend and access knowledge. Education is frequently used as an indicator in epidemiology. It serves as a strong determinant of future income and employment, and reflects intellectual, material and other resources, which makes it easier to be more receptive to health messages and be more communicative with health services. The material aspects of socioeconomic circumstances, is best measured by housing as a key component marker. Housing (like crowding, material objects, tools, household amenities and facilities) is generally the best indicator of the subjects´ wealth as a large proportion of the income is used for this (Bruna et al. 2006).

Urban clinical information

Illness

Table 1. Experience of Illnesses during the past year.

Yes, several times	25%
Yes, one time	38%
No	37%

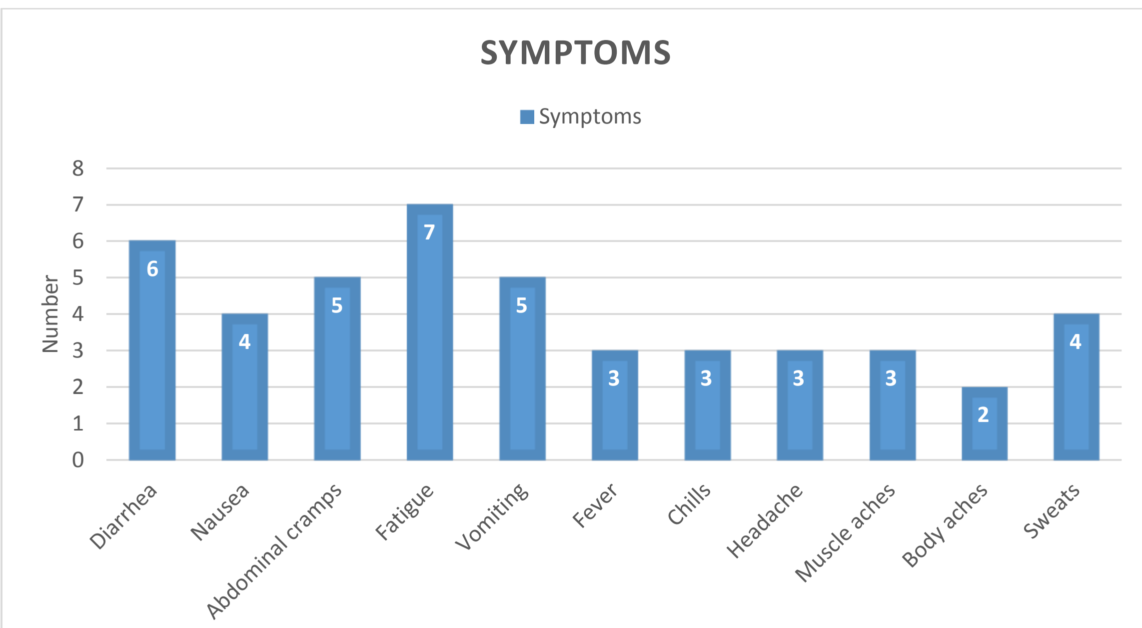


Diagram 3. Symptoms during the illness. The top three symptoms were aches, fatigue and diarrhea.

A total of 19 % of the symptom carriers went to a doctor in the city for checkup. The remaining indicated that they didn't feel the need to see a doctor. Some simply went to their local pharmacy to get medicine for their complications. A total of 6 % of the visitors had clinical tests made at the hospital and all the subjects (100 %) who got treatment for their complications were handed antibiotics. None of them got the diagnosis of waterborne infections. Although the symptoms are typical for waterborne infections, the clinical information gathered from the interviews does not indicate increased exposure among the urban respondents. Still, further investigations must be made on the reasons for the low interest in getting diagnosed to be able to trace those lacking health care confidence and/or neglecting hospital checkup for their complications. The importance of early and accurate diagnosis cannot be undermined as the possibility to determine and treat the underlying cause is only achievable by diagnosis. The increased knowledge and awareness of the body and possible contaminants or sources of infection is the first step to avoid circumstances that brings you the disease in the first place (Mabey et al. 2004).

Urban water use information

The urban population either buy their water, or use tap water (city water) as their water source. One participant described the tap water as being rusty and nonfunctional at times and some have declared that they react on the bad taste of tap water in larger cities outside Agadir. Common for all respondents is that they do not treat their drinking water before using it and that they pay for the water they use in their homes so over usage is not commonly done.

Urban values and attitudes

A total of 13 respondents answered the questions about drinking water quality. Remaining participants stated that they didn't have proper knowledge and therefor no opinion about the subject.

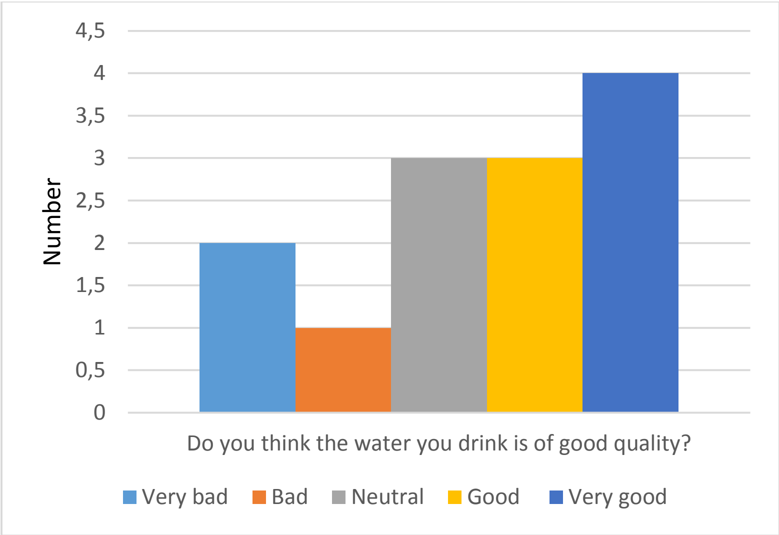


Figure 1. Opinion about the quality of drinking water. The opinions are diverse but the majority is either happy or neutral with their drinking water quality at the moment.

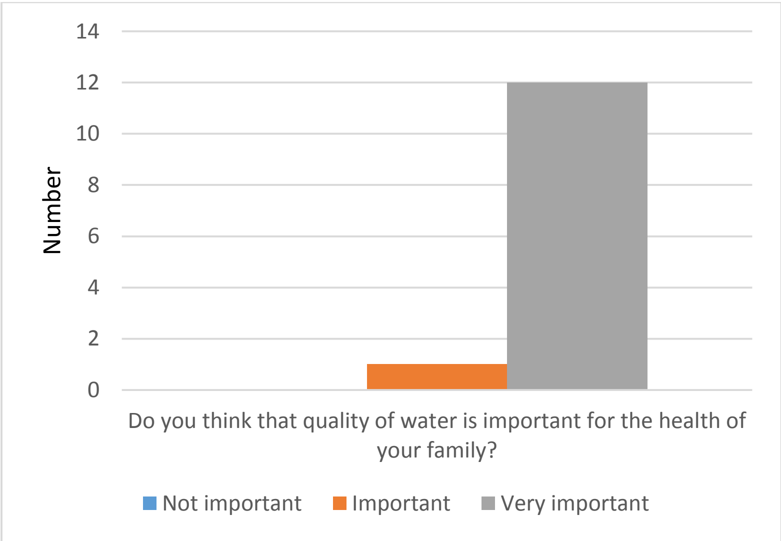


Figure 2. Opinion of the importance of good water quality. All the respondents agree on the high importance to have access to good drinking water quality in their homes.

Most important aspect of drinking water

Table 2 Opinion about the major factor of importance when it comes to drinking water. The majority agrees upon that the quality is of greatest importance.

Easy water access	6,25 %
Cheap water	0 %
Good water quality	93,75 %

Information access

Table 3 Information access show that 25 % state that they don't get any information at all about their drinking water. The remaining get their information mostly via acquaintance from staff within the water distribution companies or through media.

Authorities	12,5 %
Media	18,75 %
Acquaintance	43,75 %
None	25 %

The results indicate that the information from supervisory and local authorities, water program and monitoring committees, health service executives and environmental protection agencies must be better distributed to the locals either through media, internet, flyers or other sources to ensure citizens knowledge about factors affecting water quality (like water pollution), common water contaminants (like microbiological, chemical, leakage from septic tanks or other domestic waste water treatment), treatment of drinking water, how drinking water supplies are monitored, who is responsible for the monitoring of public water supplies, private water supplies, and small water schemes and wells. The attitudes and values of the respondents may greatly be affected by the information they get about these factors and aspects of their drinking water.

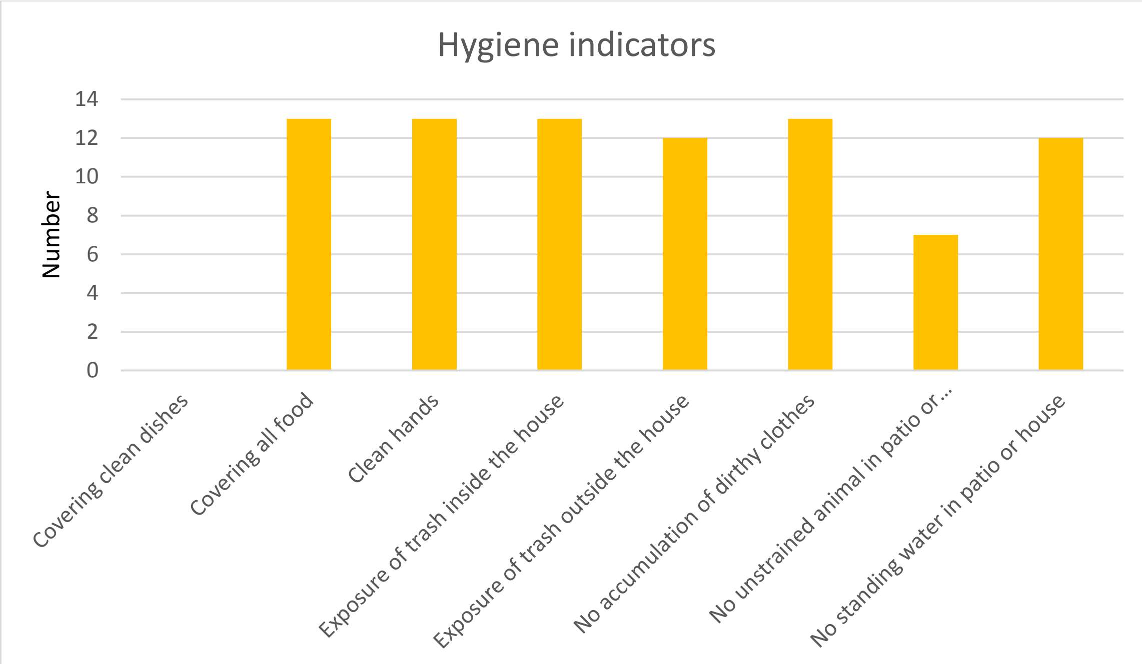


Diagram 4. Hygienic behaviors, routines and exposure in- and outside the home. The results show an overall good hygienic level with high awareness. None of the respondent cover clean dishes at home except for use of cabinets.

A significant amount of the diseases are preventable through good hygiene practices. The results of the hygiene indicators in the survey show that the urban subjects have good chances of limiting and decreasing the risks of hygiene related diseases. This can be explained by good awareness and proper knowledge and practices of handling determinants that could contaminate the water in the household (Webb et al. 2006).

Rural respondents

Because of the big difference in urban and rural interview responses, a significant comparison of the results is not possible. Still, differences in the educational level could be read out from the survey. The rural subjects did not exceed the level of secondary school. Despite the lower educational level, the awareness, knowledge and attitudes were equivalent to the urban subjects. Regarding all other parameters no major difference was presented except for the socioeconomic indicators that showed poorer circumstances among the rural subjects.

Bacterial analysis of water

Sampled by: Ms Nora Nid and Mr Aziz Madi

Date of sampling: 09/05/2014- 12/05/2014

Date of analysis: 10/05/2014-12/05/2014

NT= Not tested

Lab number	*353*	*354*	*355*	*356*	*357*
Parameters	Drarga	Amskroud	Sidi Boushab	Zawyat Issan	Rimal Tissir
Microorganisms at 22 °C/ml	$5,7 * 10^2$	$6,3 * 10^2$	$4,2 * 10^2$	$2,9 * 10^2$	$7,4 * 10^2$
Microorganisms at 37 °C/ml	$1,5 * 10^2$	$3,8 * 10^2$	$2,2 * 10^2$	$1,2 * 10^2$	$4,4 * 10^2$
Coliforms/100 ml	0	14	5	8	0
E. Coli/100 ml	0	14	5	2	0
Enterococcus/100 ml	0	26	53	8	0
Clostridia/100 ml	1	1	52	43	0

Lab number	*358*	*359*	*370*	*371*	*372*	*373*
Parameters	Oulad Teima	Tikiwin	Aghroud	Sidi Abdel Jalil	Touhamou	L'erac (Agadir city)
Microorganisms at 22 °C/ml	$1,4 * 10^2$	$4,1 * 10^2$	$3,9 * 10^2$	$6,8 * 10^2$	$8,3 * 10^2$	2
Microorganisms at 37 °C/ml	$1,1 * 10^2$	$1,5 * 10^2$	$1,7 * 10^2$	$1,3 * 10^2$	$5,4 * 10^2$	14
Coliforms/100 ml	22	>150	25	43	16	0
E. Coli/100 ml	17	NT	0	0	0	0
Enterococcus/100	55	6	0	1	22	0
Clostridia/100 ml	2	5	0	0	0	0

Table 3. The results of bacterial analysis. L´erac is the study area of Agadir city. Tikiwin had over 150 coliform bacteria per 100 ml leading to no need for E. coli detection.

The definition of Coliform bacteria are those that are lactose positive and can form colonies aerobically at 36 ± 2 °C on lactose culture medium with selective and differential production of acid within 21 ± 3 hours and are oxydase negative.

Escherichia coli are defined as a coliform bacteria that also produce indole from tryptophan within 21 (± 3) hours at 44 (± 0,5) °C. The bacteria is also resistant to bile. *Intestinal Enterococci* are bacteria capable of reducing chloride 2,3,5- Triphenyltetrazolium (TTC) in formazan. Microorganisms viable at 22 °C and 37 °C are all aerobic bacteria, yeast and mold, capable of forming colonies in a nutrient agar culture medium. Anaerob sulfite reducing microorganisms (*Clostridia*) form sulfite reducing spores belonging to the family of Bacillus and gender *Clostridium* (Norme Marocaine 2010).

Coliform bacteria

Total coliforms cover organisms that can grow and survive in water. Measurements of these can be used as an indicator of how effective the treatment is and to estimate the cleanliness and wholeness of distribution systems and presence of biofilms. However, there are better indicators for these intentions. As a disinfection indicator, direct measurement of disinfectant residual is far faster and more reliable than the test for total coliforms. Total coliforms are also far more sensitive to disinfection than intestinal viruses and protozoa. Hence, a generally considered indicator of distribution system wholeness and cleanliness are Heterotrophic Plate Count measurements that can detect a wider range of microorganisms. Total coliforms are present in both natural waters and sewage as they are heterotrophic and able to multiply in water and soil environments. They can also survive and grow in water distribution systems, preferably in the presence of biofilms. The presence of total coliforms indicates improper treatment as they should be absent immediately after disinfection (Lindberg, Lindqvist 2005). In private wells, the recommendation is less than 100 cfu/ml. The results show that the area of Tikiwin is heavily contaminated as detection over 150 cfu/ml was registered.

Escherichia coli

Escherichia coli (thermo- tolerant coliforms) is considered the most suitable index of faecal contamination. It is the first organism of choice when it comes to monitoring control programmes, such as surveillance of drinking-water quality. E. coli occurs in high numbers in animal and human feces, sewage and water subject to recent fecal pollution. It is highly unlikely that the growth of these organisms is supported by water temperatures and nutrient conditions present in drinking-water distribution systems (Lindberg, Lindqvist 2005). The presence of *E. coli* was detected in the wells of "Amskroud", "Sidi Boushab", "Zawyat Issan", and "Oulad Teima". These findings serve as an indication of recent faecal contamination, and detection should lead to planning for further action, which preferably include further sampling and investigation of potential sources such as insufficient treatment or breaches in the distribution system.

Intestinal enterococci

Intestinal enterococci can be used as an index of fecal pollution. Most species in this group do not multiply in water environments. *Intestinal enterococci* in human feces are generally lower than *E. coli*. This group has the advantages that they tend to survive longer in water environments, are more resistant to drying and are more resistant to chlorination than *E. coli*. *Intestinal enterococci* is used when testing raw water as an index of fecal pathogens surviving longer than *E. coli* and in drinking water to increase testing for *E. coli*. Furthermore, they are used when testing water quality after distribution systems repairs and after new mains have been laid. *Intestinal enterococci* are in large numbers induced in sewage and in water environments that has been polluted by sewage or wastes from animals and humans (Lindberg, Lindqvist 2005). The presence of *Intestinal enterococci* was detected in the wells of Amskroud, Sidi Boushab, Oulad Teima, Touhamou and lower concentrations in Zawyat Issan, Tikiwin and Sidi Abdel Jalil. As *E.coli*, these findings serve as an indication of recent fecal contamination, and detection should lead to planning for further action, which preferably include further sampling and investigation of potential sources such as insufficient treatment or breaches in the distribution system.

Clostridium perfingens

Clostridia produce spores that are extremely resistant to unfavourable conditions in water environments such as pH and temperature extremes, UV irradiation, and chlorination. *Clostridia* was detected in the wells of Sidi Boushab, Zawyat Issan, Oulad Teima, Tikiwin and lower concentrations in "Drarga" and "Amskroud". *Clostridium perfringens* and its spores are virtually present in sewage and potential sources of contamination should be investigated. Designed filtration processes to remove enteric viruses and protozoa should also be effective to remove *C. perfringens.*

Microorganisms in drinking water

The analysis of pathogen microorganisms is often an expensive, circumstantial and complicated process that often requires long experience and expertise. The method for water analysis on pathogenic bacteria is generally best developed and furthermore cheapest. For instance, they offer big commercial laboratories the possibility to analyze several of the most important bacterial pathogens by more or less standardized methods as the ones used in this study.

The use of indicator organisms as an instrument to estimate the risk of the presence of microbiological pathogens have many times been criticized due to a bad or sometimes absent correlation. The differences between for example survival time, the ability to grow, stress resistance, transporting patterns, excretion amounts from the host and cutoff- and inactivation degree in both purifier and waterworks have all been cited to be important reasons for the flaws of the correlation between indicator organisms and pathogens. Hence, there is a big interest in complementing existing indicators with new ones that better represents the risk of pathogen presence. Even if such need is confirmed by a wide and broad consensus, it is important to note that existing indicators play an important role in risk assessments. For example, a newly made statement based on 540 different studies of correlations between indicators and pathogens showed good equivalences but are often overlooked because of insufficient amount of samples with too small sample volumes and too low amount of positive pathogen samples.

The contamination possibilities are very diverse which testify a big amount of vulnerability points within the drinking water supply and complexity within the water production.

Regarding the uncertainty that exist around methodology and results, and in awaiting better and refined methods, it is also very important that different laboratories, as far as possible, coordinate and standardize their analyses. This is required to enable comparisons between de relatively few pathogen studies by which then facilitates further knowledge build up about pathogen presence in water. The most tangible indication of well working preparation and water distribution, and thus a microbiological safe delivery of drinking water, is the health of the consumers. A good knowledge about outbreaks and cases of illness related to drinking water consumption and the spread of these in time and space means an important basis for estimation of the flaws, where they exists and how to combat them. Waterborne illness outbreaks are obvious signals that there are flaws in the quality of drinking water.

Differences in surveillance and reporting systems are the main causes of the statistics differences. Something that strengthens this argument is the long and often complicated investigation- and reporting chain prior to registration of an outbreak at a national responsible authority or organization. Important conditions for low microbiological growth are low temperature, low volume of organic substances and low amount of microorganisms. The microbiological reason for waterborne outbreaks is reflected by the hygiene standard and what types of disease developing microorganisms that are circulating in the society.

Some microorganisms can give rise to serious and sometimes life threatening infections while others are linked to more or less serious symptoms. The consequences of personal suffering, need of health care or economic effects both on individual- and society level also varies a lot. The consequences also differ depending on who is affected. A variety of different factors thus contribute to weather one gets sick and what symptoms one develops.

Since production of drinking water is continuous the effective tool is continuous online measurements. It is not effective to wait for laboratory test results since by then the drinking water has already been distributed and used (Dryselius 2012).

Chemical analysis of water

Sampled by: Ms Nora Nid, Mr Aziz Madi, Mr Youssef Hsissou and Mr Said Boutaleb

Date of sampling: 09/05/2014- 12/05/2014

Date of analysis: 09/05/2014-12/05/2014

Sample	*1*	*2*	*3*	*4*	*5*
Source	Drarga	Amskroud	Sidi Boushab	Zawyat Issan	Rimal Tissir
Temp. (°C)	24,1	24,6	24,9	24	23
pH	6,9	6,8	6,7	6,9	7,3
Cond. (µs/cm)	4820	2590	1790	2570	1760
HCO_3^- (mg/l)	292,8	244	414,8	292,8	317,2
Ca_2^+ (mg/l)	440	560	328	224	160
Mg_2^+ (mg/l)	172,8	144	86,4	48	48
K^+ (mg/l)	5,8	3,4	3,3	4	2,6
Na^+ (mg/l)	540	32	48	205	185
SO_4^{2+} (mg/l)	446,5	995	336	24	97,8
NO_3^- (mg/l)	16	4,8	14,7	10,3	56,6
Cl^- (mg/l)	1349	248,5	678,1	674,5	308,9

Sample	*6*	*7*	*8*	*9*	*10*
Source	Oulad Teima	Tikiwin	Aghroud	Sidi Abdel Jalil	Touhamou
Temp. (°C)	23,6	24,5	22	23,1	23,8
pH	7,2	7	7,1	7,7	7,5
Cond. (µs/cm)	2280	2780	3890	2500	1732
HCO_3^- (mg/l)	488	414,8	366	244	219,6
Ca_2^+ (mg/l)	136	184	280	160	120
Mg_2^+ (mg/l)	163,2	163,2	192	96	100,8
K^+ (mg/l)	8,4	4,8	82	49	4
Na^+ (mg/l)	175	295	390	284	165
SO_4^{2+} (mg/l)	137,9	220	309,5	144,2	93,6
NO_3^- (mg/l)	36,9	9,8	33,4	350,5	10,2
Cl^- (mg/l)	399,4	639	1004,7	401,2	326,6

Table 4. The results of chemical analysis: HCO_{3-} (Bicarbonate), Ca^{2+} (Calcium), Mg^{2+} (Magnesium), K^+ (Potassium), Na^+ (Sodium), SO^4_{2-} (Sulfate), NO_{3-} (Nitrate), Cl^- (Chlorine). No chemical parameter were analyzed from the urban sample.

Chlorine

Chlorine is used as the most common oxidant and disinfectant in treatment of drinking-water. The water is supplied with a chlorine residual of a few tenths of a milligram per liter to act as a preservative during distribution. The detected level in all rural samples shows high amounts of chlorine. According to the guidelines for drinking water quality (volume 1 recommendation) the levels should not exceed 100-250 mg/L.

Nitrate

In the area of Sidi Abdel Jalil an increased level of Nitrite, over six times more than the average level of recommendation, was found. As a result of agricultural activity, nitrate can reach both surface water and ground water from oxidation of nitrogenous waste products in human and animal excreta (including septic tanks) and from wastewater disposal. Groundwater nitrate concentrations show relatively slow changes in general. In some cases, ground water may have nitrate contamination as a consequence of leaching from natural vegetation making drinking water a significant contribution to nitrate intake in human beings. Nitrate levels in drinking-water derived from surface water lies below 10 mg/liter in most countries, while in well water the levels often rises above 50 mg/liter. To achieve nitrate levels below 5 mg/liter, ion exchange should be used in ground water. All water systems that applies chlorination should regularly and closely monitor their systems in order to verify nitrite- and disinfectant levels as well as microbiological quality. If increased levels are detected then steps should be taken to modify the treatment train or the water chemistry in order to maintain a safe water quality. Efficient disinfection should never be compromised with (world health organization 2014).

pH

PH usually has no direct impact on consumers, but it is one of the most important operational water quality parameters. To ensure satisfactory water clarification and disinfection, careful attention to pH control must be done at all stages of water treatment- . The pH should be less than 8,0 for successful disinfection with chlorine. The ideal required pH will vary in different supplies depending on the construction materials used in the distribution system and the composition of the water, but it is usually ranges between 6,5–8,0. If extreme values of pH is found in water, it could be the result from treatment breakdowns, accidental spills, and insufficiently cured cement mortar pipe linings or this being applied when the alkalinity of the water is low (world health organization 2014).

Sodium

Usually the concentrations of sodium in potable water are below 20 mg/litre, but the value can be exceeded in some countries. It should be noted that water softeners can in some cases add significantly to the sodium concentration in drinking water. The highest amounts were found in the area of Drarga and Aghroud. No health guideline value for Sodium is proposed, but concentrations above 200 mg/liter may give rise to unacceptable bad taste for the consumers (world health organization 2014).

Sulfate

The highest levels of sulfate are usually present in ground water and come from natural sources. Drinking water may contain the main source of sulfur intake in areas with drinking water supplies containing high sulfate levels. The existing data do not identify a level of sulfate in drinking-water that is likely to cause adverse human health effects. Laxative effect at concentrations of 1000–1200 mg/liter may occur but there is no health guideline proposed for sulfate. However, ingestion of drinking-water with high levels of sulfate can result in gastrointestinal complications. Hence, it is recommended to inform health authorities of sources of drinking- water that contain sulfate concentrations above 500 mg/liter. In this case the area of Amskroud would be a good place for further studies on the health of the consumers based on gastrointestinal symptoms. Sulfate in drinking water can also cause changed taste and may contribute to the corrosion of distribution systems (world health organization 2014).

Temperature

Cold water is generally better in taste than warm water and temperature will have an impact on the acceptability of a number of inorganic constituents and chemical contaminants that may affect it. Higher water temperature also stimulates the growth of microorganisms and may increase color, odor, taste and corrosion problems (world health organization 2014). All samples in the study area had temperatures above 20 °C which increases the mentioned risks.

Conclusions

This field- study was performed to gather data from interviews, real- time chemical measurements and microorganism laboratory analysis in order to investigate if the study area contains contaminants affecting water quality for the villagers in southwest Morocco. The results of this study show that all ten rural water samples are classified as non-drinkable and the comparable one urban water sample is classified as drinkable according to the guidelines for water quality. A good knowledge about the number of outbreaks and incidence of waterborne infections is an important basis of judgment of where the lack exists and how to combat it.
The results from the interview show that the rural study population do not take their drinking water primarily from the sample sources but this does not exclude increased exposure to contaminated water and increased risk of getting infected by microorganisms through the use of contaminated sources for bathing, washing, swimming, cleaning, and cleaning feeding utensils. Further investigation must be made on different sources of contamination and existing factors that creates the growth of microorganisms in the study area. Based on the bacterial and chemical findings this is of high importance for prevention of potential waterborne outbreaks among the villagers. More data from rural interviews needs to be collected. Furthermore, our recommendations for policy makers, surveillance managers, clinicians and laboratory staff is to have well- structured systems and well codified preventive measures as well as creating a laboratory reporting network and computerize surveillance data and communication techniques between different stakeholders. Educating people living in the communities, involve all staff in reporting, and having regularly communicate results to Prefectural epidemiology cells in the country would facilitate the surveillance system needed to prevent any waterborne outbreaks in the region
The most tangible indication of well working preparation and water distribution, and thus a microbiological safe delivery of drinking water, is the health of the consumers. A good knowledge about outbreaks and cases of illness related to drinking water consumption and the spread of these in time and space means an important basis for estimation of the flaws, where they exists and how to combat them. Waterborne disease outbreak is an obvious signal that there are flaws in the quality of drinking water.

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