RAPID ASSESSMENT OF DRINKING-WATER QUALITY IN THE REPUBLIC OF NICARAGUA

COUNTRY REPORT

Evaluación Rápida de la Calidad del Agua de Bebida, Nicaragua

World Health Organization

unicef

RAPID ASSESSMENT OF DRINKING-WATER QUALITY IN THE REPUBLIC OF NICARAGUA

COUNTRY REPORT OF THE PILOT PROJECT IMPLEMENTATION IN 2004-2005

Prepared by

Jorge Mendoza Aldana

2010

WHO Library Cataloguing-in-Publication Data

Rapid assessment of drinking-water quality in the Republic of Nicaragua: country report of the pilot project implementation in 2004-2005 / by Jorge Mendoza Aldana.

1.Potable water - standards. 2.Water quality - standards. 3.Water - standards. 4.Nicaragua. I.Mendoza Aldana, Jorge. II.World Health Organization. III.UNICEF.

ISBN 978 92 4 150058 6 (NLM classification: WA 675)

Editorial support: Kevin Farrell, Federico Properzi

Photo Credit: Jorge Mendoza Aldana

Table of contents

Annexes

List of figures

List of tables

Foreword

One of the targets of the Millennium Development Goals, promulgated by the United Nations in 2000, is to halve by the year 2015 the proportion of people without sustainable access to safe drinking-water and adequate sanitation, thereby reducing the burden of associated disease. Unfortunately, recent statistics on water and sanitation do not provide specific evidence about the quality of water being provided to communities, households and institutions, and the safety of the drinking-water supply can only be inferred. There is, therefore, an urgent need to obtain independently verifiable water-quality data to help national governments provide safe water to households. Such data would provide useful information about current conditions and the likely public-health burden related to an inadequate and unsafe water supply. The data would also reveal the extent of major water-quality problems and inform future investment priorities. To fill this information gap, the World Health Organization and the United Nations Children's Fund (WHO/UNICEF) developed a low-cost method for rapidly assessing the quality of drinking-water in a country. Six countries volunteered to host pilot projects to test the new method, termed a Rapid Assessment of Drinking-Water Quality (RADWQ) survey: China, Ethiopia, Jordan, Nicaragua, Nigeria and Tajikistan.

In Nicaragua, the RADWQ survey was carried out during the second half of 2004 under the supervision of an executive committee and a technical committee (for nthe composition of these committees, see Annex 1). The executive committee (Comisión Nacional de Agua Potable y Alcantarillado Sanitario, CONAPAS) consisted of directors from the Nicaraguan Institute of Drinking-water Supply and Sewage Systems (Instituto Nicaragüense de Acueductos y Alcantarillados, INAA); the Nicaraguan Company of Drinking-water Supply and Sewage Sytems (Empresa Nicaragüense de Acueductos y Alcantarillados Sanitarios, ENACAL); the Environmental Health Department of the Ministry of Health (Ministerio de Salud, MINSA); and representatives from the Ministry of Natural Resources and Agriculture (Ministerio del Ambiente y Recursos Naturales, MARENA), and the Nicaraguan Water and Sanitation Network (Red de Agua y Saneamiento de Nicaragua, RASNIC). The technical committee consisted of water-sector experts from ENACAL, INAA, MINSA, the Programme of Research and Training in Environment at the National Engineering University (Centro de Investigación y Estudios en Medio Ambiente, CIEMA-UNI), UNICEF and PAHO (Pan American Health Organization).

International consultants trained the field personnel in RADWQ survey methodologies prior to field activities. The training included survey design, field implementation, use of field testing equipment and sanitary inspection methods. A total of 1488 water samples were taken from four broad administrative areas in Nicaragua for the RADWQ survey and analysed for chemical and microbiological quality. The water sources were analysed in clusters that were selected so as to be representative of water sources across the entire country and thus to provide a snapshot of the quality of water sources nationwide. After all the field activities had been completed, there was a final review of the project with the technical committee and the international consultant, resulting in recommendations for improving the RADWQ methodology.

Acknowledgements

The author would like to acknowledge the tireless collaboration and important roles played by the organizations and individuals who participated in the RADWQ study in Nicaragua. Special mention goes to UNICEF for providing constant support and for making important contributions throughout the RADWQ evaluation process and to the content of this document. The financial support received from the Department for International Development/UKAID of the United Kingdom is gratefully acknowledged.

Acronyms

CIEMA-UNI	Centro de Investigación y Estudios en Medio Ambiente, Universidad Nacional de Ingeniería
CONAPAS	Comisión Nacional de Agua Potable y Alcantarillado Sanitario
ENACAL	Empresa Nicaragüense de Acueductos y Alcantarillados Sanitarios
INAA	Instituto Nicaragüense de Acueductos y Alcantarillados
JMP	WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation
MARENA	Ministerio del Ambiente y Recursos Naturales
MINSA	Ministerio de Salud
PAHO	Pan-American Health Organization
RASNIC	Red de Agua y Saneamiento de Nicaragua
UNICEF	United Nations Children’s Fund
WHO	World Health Organization

Executive summary

During 2004 and 2005 the Republic of Nicaragua and five other countries participated in a World Health Organization/United Nations Children's Fund (WHO/UNICEF) pilot project to test a rapid, low-cost, field-based technique for assessing water quality. The project was named the Rapid Assessment of Drinking-Water Quality (RADWQ) and its purpose was to develop a tool that would help the WHO/UNICEF Joint Monitoring Programme (JMP) monitor global access to safe drinking-water, as a means of assessing progress towards the water and sanitation target of the Millennium Development Goal 7. The RADWQ methodology is based on the UNICEF Multiple Indicators Cluster Surveys, which use cluster sampling across a country to select individual drinking-water sources for testing. The number and types of parameters used to test the drinking-water sources depend on the extent of the survey and on local potential health hazards. The output of a RADWQ survey is a snapshot of drinking-water quality for each improved water source tested.

Using the RADWQ methodology, four teams of field personnel visited 1488 water supplies throughout Nicaragua over a period of seven weeks from 25 October to 10 December 2004. The samples were taken from four broad areas, geographically defined to reflect the water situation of the country as a whole: Pacific, Atlantic, Central North and Central South. The capital city of Managua is located in the Pacific broad area. Four types of technologies were examined: public piped water supplies; community water systems; boreholes/tubewells; and, protected wells. The water samples were analysed using portable field kits, and were tested for the following water quality parameters: thermotolerant coliforms, faecal streptococci, pH, turbidity, chlorine residuals, appearance, conductivity, arsenic, fluoride, nitrate and iron. For 10% of the water samples it was also analysed whether the water quality had deteriorated between the water source and the household. Sanitary risk inspections were carried out at each of the 1488 sites, using standardized questionnaires.

The RADWQ survey results provide a statistically representative snapshot of the water and sanitation status of Nicaragua. Extreme values of pH were seen for all types of water delivery technology, with the exception of public piped water supplies. However, over one-third of the public piped water supplies had levels of residual chlorine that were inadequate for disinfection, as did over 97% of water samples from the other technologies assessed. Many water sources had extremely high values for turbidity and electrical conductivity, particularly protected wells in the Atlantic broad area. High levels of iron were detected in some public piped supplies in the Pacific broad area, and in boreholes (tubewells) and protected wells in the Central North broad area. In contrast, most water supplies in Nicaragua were in compliance with the WHO guideline values for arsenic and fluoride. None of the 895 water samples analysed for nitrate exceeded the WHO guideline value.

Many of the water supplies had medium or high sanitary risk levels, even public piped-water supplies, and 15.7% of the water supplies had unacceptable levels of sanitary risk (high and very high). To the extent that the same situation continues to prevail, these figures show that the sanitary integrity of the water supplies is in jeopardy. Protected wells from the departments of Río San Juan and Matagalpa had a 60% sanitary inspection score, which merits immediate action. Community supplies in the departments of Boaco, Jinotega and Matagalpa, as well as public piped-water supplies in Rivas department, had sanitary inspection scores of 50%, suggesting these water supplies need to be carefully monitored.

1. Introduction

1.1 From Alma Ata to the Millennium Development Goals

The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) proposed a new concept of health in the 1978 Declaration of Alma Ata, as a way of moving towards the goal of health for all by the year 2000 (HFA2000). The declaration promoted a human rights approach to health, in which access to safe water and adequate sanitation was considered to be a human right and a minimum requirement of primary health care. This approach was based on two ideas: that governments are responsible for guaranteeing basic health services; and that the people should set the priorities for health-care services.

At the start of the twenty-first century, the global picture has drastically changed, the noble ideals of Alma Ata have proved to be untenable and the governments and members of the international community who supported the Declaration have been unable to meet their obligations. In part, this is the result of changes in economic philosophy during the 1990s that replaced the concept of government-based primary health care with one based on free-market forces, in which health and health-care services were viewed as commercial goods and as nonproductive costs for the state. The scale of the failure to attain HFA2000 is apparent from the numbers – in that year approximately 1 billion people did not have access to safe drinking-water and 2.4 billion did not have access to proper sanitation (WHO/UNICEF, 2000).

In September 2000 the 189 members of the United Nations adopted eight Millennium Development Goals to promote human development. The goals are based on the belief that a country can reach sustainable social and economic development if resources are invested in the development of its citizens. Some targets include: "*To halve, by the year 2015, the proportion of the world's people whose income is less than one dollar a day and the proportion of people who suffer from hunger and, by the same date, to halve the proportion of people without sustainable access to safe drinking-water and basic sanitation*". The drinking-water target again emphasizes access to safe drinking-water, a concept established in the Alma Ata Declaration. In practice, achieving the drinking-water target will require that an additional 100 million people are provided with access every year until 2015. It also implies that by 2015, some 700 million people will still be without access to safe drinking-water.

1.2 The WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation

In 1990, WHO and UNICEF united their efforts to monitor progress towards global coverage targets for water and sanitation by establishing the Joint Monitoring Programme (JMP). The JMP monitors trends in coverage; helps developing countries strengthen their monitoring capacity; standardizes questionnaires, indicators and definitions to ensure that information is comparable over time and between countries; and informs policy-makers and decision-makers on the status of the water supply and sanitation. The JMP database is the source for WHO and UNICEF coverage estimates for drinking-water supplies and sanitation facilities, and at the time the most recent JMP report was published (March 2010) it contained over 1200 national household surveys and censuses.

Before 2000, coverage data were based on information from service providers, such as public agencies and ministries, rather than from household surveys. The quality of the information varied because data from suppliers frequently did not include water or sanitation works constructed by household members (e.g. private wells or simple latrines), nor even systems installed by local communities. Moreover, government definitions of improved water supplies and sanitation facilities changed over time. In 2000, JMP decided to use household surveys and to standardize definitions, which provided a more precise picture of the services and works used by people. Effectively, the information now comes from the users of services, rather than from the suppliers. The use of household surveys significantly increased the quality and comparability of the information on improved drinking-water supplies and sanitation. This information is more useful to policy-makers, as it provides standardized indicators and survey questions, and also allows for the measurement of certain disparities, for example for gender of between rural and urban populations.

In the past, the JMP drew guidance from a technical advisory group of leading experts in water supply, sanitation and hygiene, and from institutions involved in data collection and sector monitoring. With the formulation and adoption of the JMP Strategy for 2010-2015, this technical support structure will be further strengthened. The JMP strategy further states the vision and mission of the JMP as, respectively: *To accelerate progress towards universal, sustainable, access to safe water and basic sanitation by 2025*[1]*, including the achievement of the MDG targets by 2015 as a key milestone* and *to be the trusted source of global, regional and national data on sustainable access to safe drinking-water and basic sanitation, for use by governments, donors, international organizations and civil society.*

To fulfil its mission, the JMP has three strategic objectives:

- to compile, analyse and disseminate high quality, up-to-date, consistent and statistically sound global, regional and country estimates of progress towards internationally established drinking-water and sanitation targets in support of informed policy and decision making by national governments, development partners and civil society;
- to serve as a platform for the development of indicators, procedures and methods aimed at strengthening monitoring mechanisms to measure sustainable access to safe drinking-water and basic sanitation at global, regional and national levels;
- to promote, in collaboration with other agencies, the building of capacity within government and international organizations to monitor access to safe drinking-water and basic sanitation.

These priorities translate into four strategic priorities for the JMP over the next five years:

- maintaining the integrity of the JMP data base and ensuring accurate global estimates:
- dissemination of data to sector stakeholders;
- fulfilling JMP's normative role in developing and validating target indicators;
- interaction between countries and the JMP

The JMP defines access to drinking-water and sanitation in terms of the types of technology and levels of service afforded (Table 2.1). For drinking-water, at the time of this study this includes house connections, public standpipes, boreholes with handpumps, protected dug wells, protected springs and rainwater collection; allowance is also made for other locally-defined technologies.

1.3 The WHO/UNICEF Rapid Assessment of Drinking-Water Quality pilot study

Monitoring progress towards the Millennium Development Goal for water and sanitation is complex. Part of the complexity stems from trying to standardize the definition of "drinking-water", which JMP currently defines as water used for domestic purposes, including drinking and hygiene. A further problem is the lack of a reliable technique for measuring the safety and quality of water supplies, both at their origins and in households. As a result, so-called "improved" sources of water (see Table 2.1 below for the JMP definitions of improved sources) may contain potentially toxic substances or the water may be contaminated during transportation or storage. In several regions of the world, dangerous levels of chemicals, such as arsenic and fluoride, are detected with increasing frequency in groundwater resources. The number of people using truly safe water supplies is, therefore, likely to be significantly lower than the number reported to be using improved water supplies.

In response, WHO and UNICEF, with support from the Government of the United Kingdom, carried out pilot studies of a method to rapidly assess the quality of drinking-water with a high level of confidence. The countries participating in the pilot studies were China, Ethiopia, Jordan, Nicaragua, Nigeria and Tajikistan. The goal was to develop an efficient method for rapidly assessing water quality and to collect baseline data that could serve as a source for water safety information, which will make it possible to detect future trends and challenges in the sector. To ensure that the results collected by the method were statistically representative of the water supplies in a country, the JMP developed a theoretical framework, the Rapid Assessment of Drinking-Water Quality (RADWQ), which is described in the RADWQ draft handbook (Howard, Ince & Smith, 2003). The RADWQ pilot study was implemented in Nicaragua during the second semester of 2004 and the results are described in the present report.

1.4 Country background

Nicaragua is located in Central America, approximately between latitudes 11°N and 15°N, and longitudes 83°W and 88°W, encompassing a total area of 129 494 square km, 9240 square km of which is water. To the north, it is bordered by Honduras, and to the south by Costa Rica. Flat coastal lowlands of the eastern and western seaboards border the Caribbean Sea and the Pacific Ocean, respectively, and rise to a central mountainous region with several volcanoes. Generally, the climate is warmer and more humid in the lowland areas, compared with the higher elevations.

According to United Nations Population Division, the 2005 population of Nicaragua was approximately 5.5 million, with a life expectancy at birth (male, female) of 68/75 years, and a national per capita gross domestic product of US$ 3650. The economy is largely based on agriculture and services, and industrial development is relatively limited, although the recent adoption of the Central America Free Trade Agreement (CAFTA) should improve export opportunities for both the agricultural and industrial sectors. Remittances from abroad (mainly from Costa Rica and the United States of America) currently make a significant contribution to the gross domestic product.

Administratively, the country is divided into 17 departments, organized within three larger regions: Pacific, Central and Atlantic. In the RADWQ study for Nicaragua, the Central region was further subdivided into Central North and Central South regions (referred to as "broad areas" in the RADWQ study). The Pacific region includes the capital city, Managua, located on the banks of the eponymous lake, and this region has the highest population density of all the regions. The Central region is largely rural with an agrarian economy; and the Atlantic region is mainly jungle with few roads and a very low population density.

Nicaragua has abundant rainfall and many water bodies, yet despite this, a large proportion of the population does not have access to clean water. The two largest water bodies are lakes Managua and Nicaragua, which could serve as potential sources of clean water, but they are in danger from tourism and overdevelopment. There are only two seasons: a dry season that runs from January to April, and a rainy season that runs from May to December. Rainfall can vary significantly depending on elevation and location. Along the Caribbean Mosquito Coast, for example, annual rainfall averages between 250 and 600 cm; Managua averages about 110 cm; and the Pacific Coast about 100 cm a year.

1.5 State of the water and sanitation sector in Nicaragua

In 1998, the Administration of Arnoldo Alemán reformed the water and sanitation sector by separating the government bodies responsible for policy (CONAPAS), regulation (INAA) and service provision (ENACAL). However, the reforms did not emphasize decentralization of the sector, nor the establishment of public-private partnerships. Although the financial condition of ENACAL improved between 1998 and 2001, this was achieved by raising the tariffs, which caused public protests. During the Bolaños administration (2002–2007) the tariffs were frozen, which has left INAA largely functionless since one of its main roles was to approve tariff increases.

In October 2005, CONAPAS once more approved a strategy that was designed to decentralize management of the water and sanitation sector, strengthen the role of the regulator (INAA) and enable CONAPAS to become financially self-sufficient. At the beginning of 2007, CONAPAS initiated a comprehensive 10-year plan for the water and sanitation sector. The plan was to invest US$ 592 million in the sector, with a focus on rural populations. However, any movement towards decentralization of the sector was reversed in mid-2007 when the administration of Daniel Ortega took over two municipal systems (in Matagalpa and Jinotega). The Ortega administration is generally opposed to public-private partnerships, and is considering forming a National Water Authority.

Three national laws, promulgated in 1998, define the roles and responsibilities of the entities involved in the water and sanitation sector in Nicaragua.

- law number 297, the General Drinking-Water and Sewerage Services Law;
- law number 276, which created ENACAL;
- law number 275, which reformed INAA into a regulatory body;

A General Water Law was also passed in September 2007, which focuses on water resources in the country.

Responsibility for setting policy in the water and sanitation sector is vested in CONAPAS, which comprises representatives from ENACAL, INAA, MARENA, MINSA and RASNIC (Annex 1).

2. Methods

2.1 The general design of a RADWQ survey

The general design of a RADWQ survey is described in detail in the RADWQ draft handbook (Howard, Ince & Smith, 2003), and the recommended stages are shown in Figure 2.1. Briefly, the survey design uses multistage stratified cluster sampling to identify the number, type and location of water supplies to be included in the assessment. Cluster sampling means that the water supplies included in the assessment are geographically close to one another (in "clusters"), but are representative of all water supply technology types. This allows to lower costs (e.g. by reducing transportation costs to/from the sampling points), without compromising the statistical validity of the sampling method. This method is used in a RADWQ survey because it is already used in major international surveys of water, sanitation and health that contribute to the WHO/UNICEF JMP database (such as the Multiple Indicators Cluster Surveys).

To try to ensure that the results of a RADWQ survey accurately reflect the situation in a country, only improved technologies supplying at least 5% of the population are included in the survey. The basic sampling unit is the water supply, rather than the individual households that use it, because an assessment of a statistically significant number of households would be prohibitively expensive. Thus, a RADWQ survey primarily assesses the quality and sanitary condition of the water supplies, and hence the risk to water safety. For a limited number of households, a RADWQ survey also compares the quality of water stored in households with that of the matched source.

2.2 Definitions

Water supply

A water supply is a means by which water is provided to households. A water supply can be a perforation (tubular well), a protected spring, or a storage and conveyance system. A piped water system can be publicly of community administered.

Types of technology

The JMP defines water sources as "improved" or "unimproved", based on accessibility, technology type and level of service afforded (Table 2.1). Since not all people who have access to improved supplies use them, JMP adopted the use of the water source as the primary indicator for monitoring progress in the water and sanitation sector.

Technologies included in this study are:

- Borehole (also called a tubewell);
- Protected dug well;
- Protected spring;
- Vehicle/animal tanker services[1];
- Community-managed rainwater catchment systems;
- Public piped-water systems (i.e. systems managed by an organization, such as a local government or private operator, that is distinct from the community it serves);
- Community-managed systems (i.e. systems managed by the community they serve). Examples include water supplies managed by a water-user association or group, where all members are drawn from the community.

[1] This is an exception to the RADWQ method. It was meant to verify the level of non-protection of this water supply source.

Figure 2.1 **General design of a RADWQ survey**

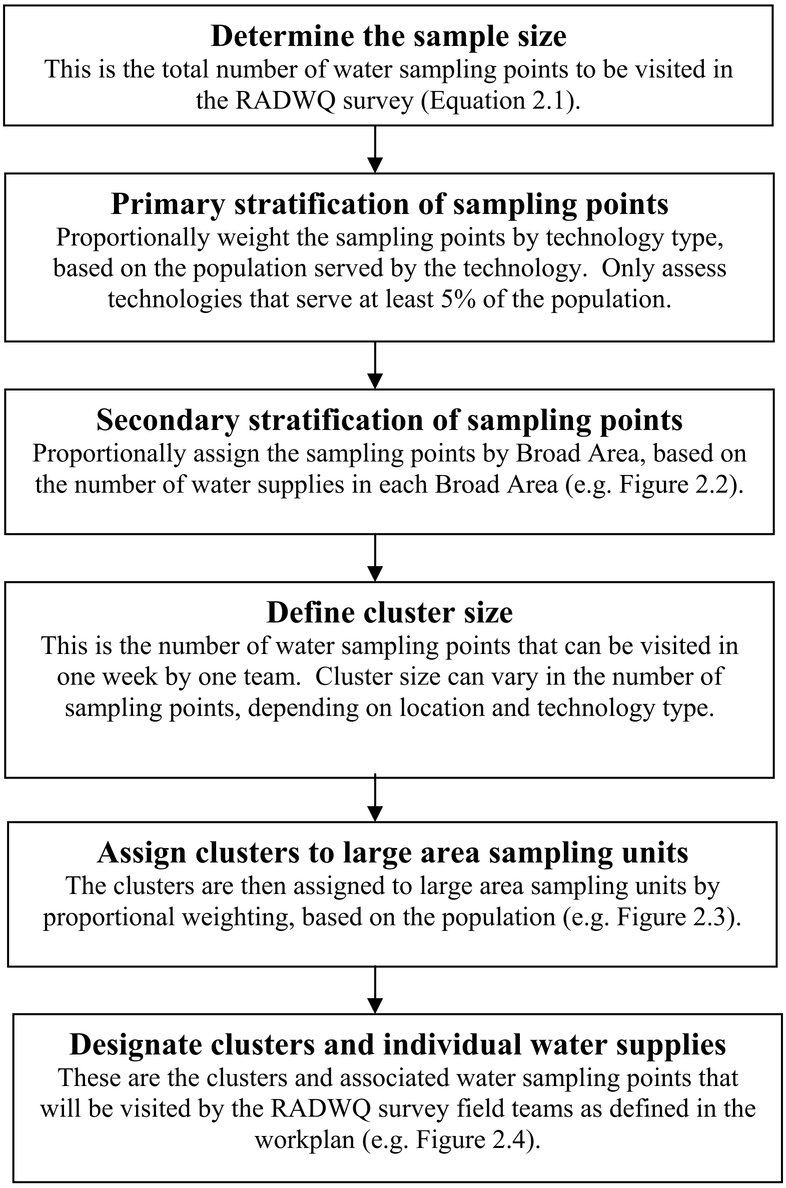


Table 2.1 **JMP definitions of water supply and sanitation (2004)**

Category	Water supply	Sanitation
Improved	• Household connection • Public standpipe • Borehole • Protected dug well • Protected spring • Rainwater collection	• Connection to a public sewer • Connection to septic system • Pour-flush latrine • Simple pit latrine • Ventilated improved pit latrine
Unimproved	• Unprotected well • Unprotected spring • Vendor-provided water • Bottled water[a] • Tanker truck-provided water[b]	• Service or bucket latrines (where excreta are manually removed) • Public latrines • Latrines with an open pit

[a] Considered to be "unimproved" because of concerns about the quantity of supplied water, not because of concerns over the water quality.

[b] Considered to be "unimproved" because of concerns about access to adequate volumes, and concerns regarding inadequate treatment or transportation in inappropriate containers.

Sample size estimation

The sample size required in rapid assessments of water sources is determined primarily by the expected microbiological quality of the water supplies to be assessed (P, in Equation 2.1), with some minor adjustments for pollution by chemical agents. The number of samples to be assessed is calculated from Equation 2.1, which is explained in detail in the RADWQ draft handbook (Howard, Ince & Smith, 2003):

$$n = \frac{4P(1-P)D}{e^2} = \frac{4 * 0.5(1-0.5) * 4}{0.05^2} = 1600 \qquad \text{(Equation 2.1)}$$

where:

n = required number of samples;
P = assumed proportion of water supplies with a water quality exceeding the target established;
D = design effect;
e = acceptable precision expressed as a proportion.

Stratification and clusters

After the total number of water sampling points has been calculated, the water sampling points are stratified, first according to the types of technology in the country that serve ≥5% of the population, and then according to broad areas within the country and on cluster size (the number of sampling points that can be visited by a team in one week). The purpose of the stratification is to ensure that the water sampling points are weighted by technology type and by region of the country according to the population served.

2.3 The RADWQ survey for Nicaragua

An executive committee and a technical committee were established, following the recommendations of the RADWQ steering committee for Nicaragua (Annex 1). The executive committee, Comisión Nacional de Agua Potable y Alcantarillado Sanitario (CONAPAS), comprised directors of INAA, ENACAL and MINSA, as well as representatives from MARENA and RASNIC. The technical committee comprised officials of UNICEF, PAHO/WHO, and water sector experts from INAA, ENACAL, the Environmental Health Department of MINSA and the Programme of Research and Training in Environment of the National Engineering University (CIEMA-UNI).

RADWQ survey design

The design of the RADWQ survey in Nicaragua began with two weeks of training for national staff of the Ministry of Health and ENACAL. The training was carried out by Sam Godfrey, an international consultant contracted by UNICEF and WHO, in consultation with the technical committee. The theoretical framework for calculating the number of water sampling points to be visited (1600) was discussed during training, using the Spanish language version of the JMP RADWQ draft handbook (Howard, Ince & Smith, 2003). The Spanish language teaching aids used for the initial training are shown in Annex 2.

Baseline information used in the RADWQ survey for Nicaragua came from rural and urban databases provided by ENACAL, which administers approximately 80% of the water supplies in the country. Databases from other organizations were not available. Analysis of the data showed that it was unrealistic to first stratify the data among technologies serving ≥5% of the population, as recommended in the RADWQ draft handbook, because this would have excluded a significant proportion of the population, largely rural (Table 2.2). Consequently, it was decided to divide the country into four broad areas and to first stratify the total number of sampling points according to the population served in each broad area (Table 2.2, Figure 2.2). Secondary stratification of the sampling points was then by technology type within each broad area, excluding those providing water to less than 5% of the population of each broad area (Table 2.3, Figure 2.3). Final agreement on the number of broad areas came after debate during training, in which members of the technical committee participated. Four broad areas were chosen: Pacific, Central North, Central South and Atlantic (Figure 2.2).

Table 2.2 **Water-supply coverage for Nicaragua, by technology and broad area**

Technology	Broad area							
	Pacific		Central North		Central South		Atlantic	
	(*N*)	(%)[a]	(*N*)	(%)	(*N*)	(%)	(*N*)	(%)
Public supply	2 487 475	93.9	511 119	55.3	185 535	79.2	38 143	32.9
Community supply	18 251	0.7	242 056	26.2	8 448	3.6	36 001	31.0
Borehole/tubewell	68 450	2.6	104 668	11.3	18 315	7.8	20 553	17.7
Protected well	75 910	2.9	65 737	7.1	21 892	9.3	18 095	15.6
Rain water	0	0.0	1 284	0.1	0	0.0	13	0.0
Cisterns	0	0.0	0	0.0	0	0.0	3 245	2.8
Population totals for each broad area	2 650 086		924 864		234 190		116 050	

[a] Percentages were calculated from the total population (*N*) in each Broad Area, not from the total population for the country.

Figure 2.2 **Broad areas used in the primary stratification of water sampling points**

Figure 2.3 **Location of clusters, by broad area and technology**

The next step was to define cluster size and determine their location, based on the number of water supplies assigned to each broad area and the technology type used (Table 2.3). According to the RADWQ draft handbook, cluster size is defined as the number of water samples a field team can process in one week of work. Cluster size therefore varies according to the difficulty of accessing water sampling points in the field. The numbers of clusters for each broad area and technology type were then calculated simply by dividing the number of samples in each category by the cluster size assigned for that category (Table 2.4). The final number of assigned clusters was rounded to the nearest integer and did not necessarily add to the number of samples previously calculated for each broad area and technology.

Table 2.3 **Number of assigned water supplies in each broad area, by technology**

Technology	Broad area				Total and assigned numbers of samples for all broad areas, by technology
	Pacific	Central North	Central South	Atlantic	
Public supply	669	119	64	18	870
Assigned samples[a]	278	49	27	7	361
Community supply	0	720	0	56	776
Assigned samples	0	299	0	23[b]	322
Borehole	0	884	167	0	1051
Assigned samples	0	368	69	0	437
Protected well	0	843	135	177	1155
Assigned samples	0	350	56	74	480
Total water supplies	669	2566	366	251	3852
Total assigned samples	278	1066	152	104	1600

[a] The numbers of assigned samples were calculated from the total number of water supplies in each broad area.
[b] Although these samples are listed under the Atlantic broad area, they are located in a municipality administered by a department in the Central South broad area.

For Nicaragua, a cluster corresponded to the water supplies in a municipality. Some municipalities had fewer water supplies than the minimum size defined for a cluster. In such cases, the municipalities were combined with the geographically closest municipality until the requisite number of supplies was reached. This occurred with a large number of rural municipalities, ultimately resulting in 50 groups of clusters distributed across 13 of the 17 departments of Nicaragua (Figure 2.3; Table 2.4). The selection of these groups for the RADWQ assessment followed the method in the RADWQ draft handbook (Howard, Ince & Smith, 2003). The final numbers of water samples assessed for each department are given in Table 2.5 for each of the technologies.

The total number of samples collected and registered in the SanMan database was 1500, plus 145 samples from households and 167 double samples. After screening the data for quality control, the final number of samples for analysis was 1488, plus 145 samples from households and 151 double samples. The distribution of the 1488 samples is given in Table 2.6, by broad area and technology type. The software program STATA®, version 7, from Stata Corporation, College Station, Texas, USA, was used for the statistical analyses of the data.

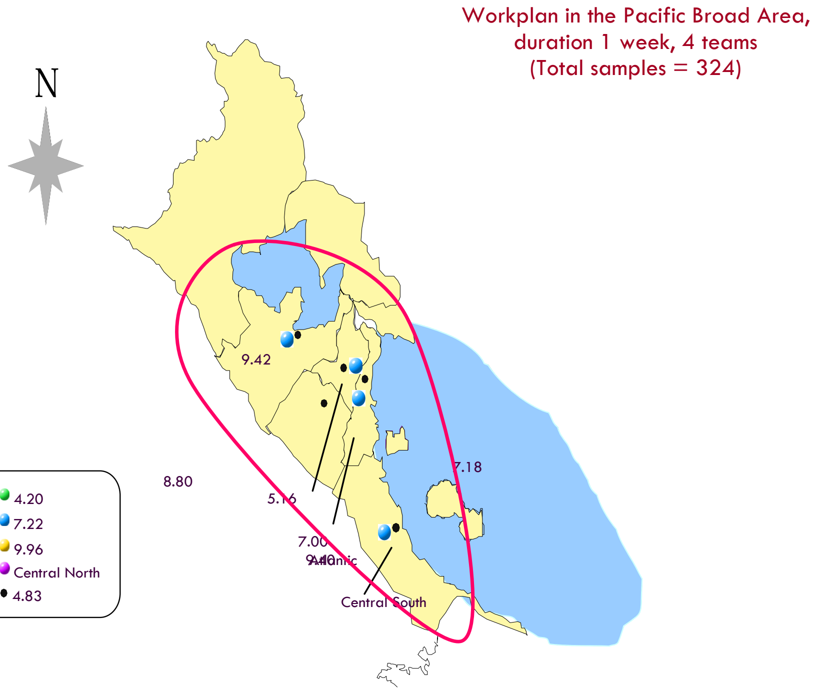
Table 2.4 Cluster number and size for each broad area, by technology

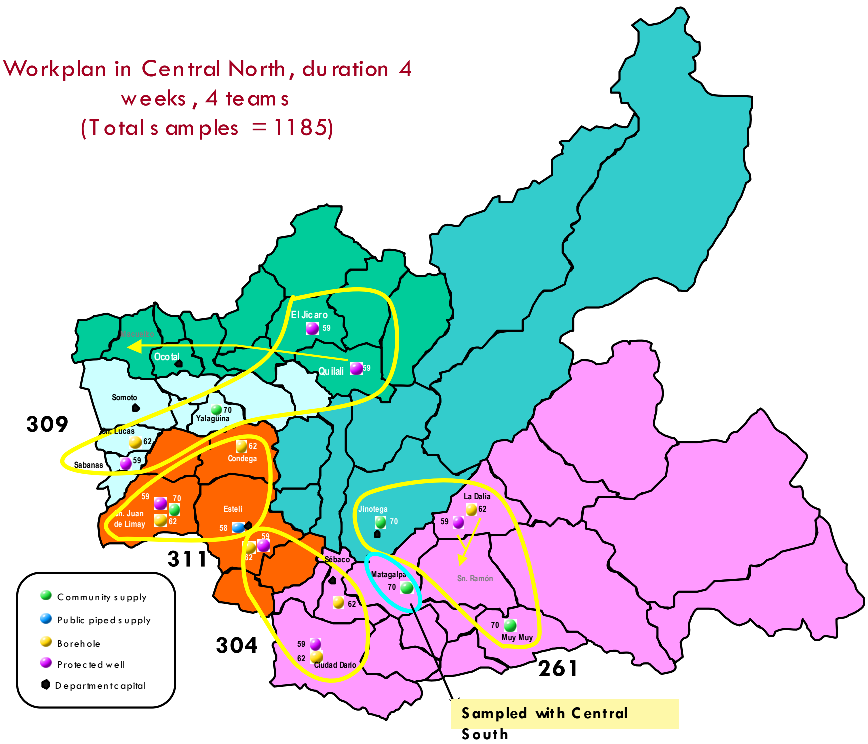
Technology	Broad area				Totals
	Pacific	Central North	Central South	Atlantic	
Public supplies	278	49	27	7	361
Cluster size	65	30	9	10	
# of clusters	4	1	3	1	9
Community supplies	0	299	0	23	322
Cluster size	0	50	0	10	
# of clusters	0	5	0	2	7
Boreholes	0	368	69	0	437
Cluster size	0	50	10	0	
# of clusters	0	7	6	0	13
Protected wells	0	350	56	74	480
Cluster size	0	50	8	10	
# of clusters	0	7	7	7	21
Total samples	278	1066	152	104	1600
# of clusters	4	20	16	10	50

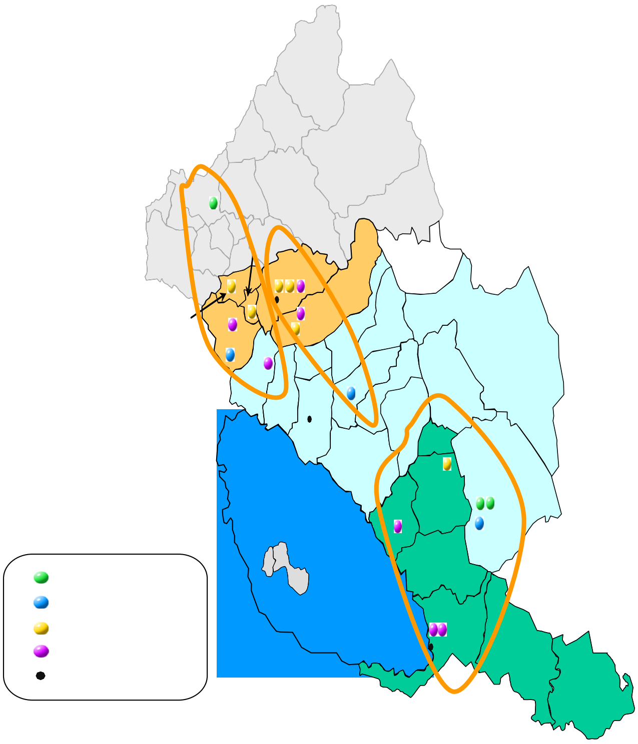
Table 2.5 Number of water samples assessed, by department and technology

Department	Technology				Department totals, all technologies	% of total samples, by department
	Public	Community	Borehole	Protected well		
Boaco	0	12	69	43	123	8.3
Chontales	29	29	2	17	78	5.2
Estela	58	30	160	105	353	23.7
Granada	65	0	0	0	65	4.4
Jinotega	0	51	0	0	51	3.4
Madriz	0	8	56	33	97	6.5
Managua	43	0	0	0	43	2.9
Masaya	65	0	0	0	65	4.4
Matagalpa	0	105	145	85	335	22.5
Nueva Segovia	0	0	9	83	92	6.2
Rió San Juan	0	29	1	11	41	2.8
Rivas	65	0	0	0	65	4.3
RAAN	10	1	0	69	80	5.4
National totals, by technology	335	265	442	446	1488	100.0
% of total samples assessed, by technology	22.5	17.8	29.7	30.0	100.0	

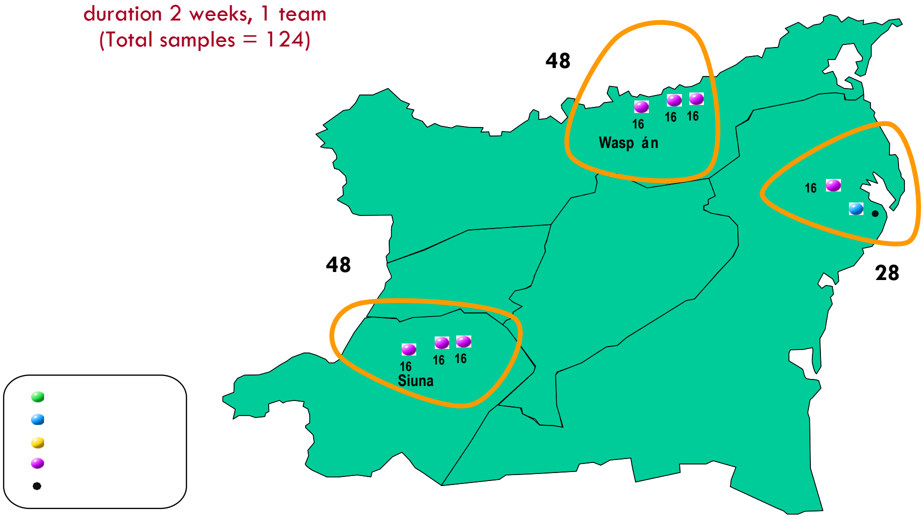
Figure 2.4 **Workplan for each broad area, by technology type**







Workplan in the Atlantic Broad Area,
duration 2 weeks, 1 team
(Total samples = 124)



The numbers of community water supplies assigned for analysis in the Central South and Atlantic broad areas (0 and 23, respectively, Table 2.3), are different from the numbers of assessed community water sources listed for these broad areas (70 and 1, respectively, Table 2.6), because all but one of the water supplies located in the Atlantic broad area were administered by a department within the Central South broad area and thus listed in that area.

Table 2.6 **Number of water samples analysed, by broad area and technology type**

Broad area	Public	Community	Tubewell	Protected dug well	Broad area totals
Pacific	238	0	0	0	238
Central North	58	194	370	306	928
Central South	29	70	72	71	242
Atlantic	10	1	0	69	80
Totals	335	265	442	446	1488

Implementation of the RADWQ field work

Data collection began after the initial training to define an appropriate workplan and schedule for field activities. This involved adjusting the calculated total number of samples to be evaluated (including double samples and household samples), which helped to establish the daily work load. The field personnel underwent fresh training on all evaluation procedures before the field work began. Four portable analysers for bacteriological and physicochemical analyses were available, as well as four WagTech™ arsenators acquired by UNICEF. Two of the arsenators were digital, the others manual. Because of their precision, the digital arsenators were assigned to places where arsenic was known to contaminate water supplies, which meant that approximately 85% of all the water samples were assessed using a digital arsenator. Although the two types of equipment had different precisions, both were sufficient to determine whether the arsenic concentration in the water samples met the WHO guideline value of 0.01 mg/l.

The recommendations of the international consultant were modified to make most efficient use of time in the field, to optimize the use of human resources, and to maximize the daily work load and number of water samples processed. The modifications included:

- Locating the laboratory equipment in a strategic place, with the fewest elements necessary to guarantee good operation of the equipment, and good handling, transportation and processing of samples. Samples were collected until 14:00 every day by two members of the team.
- Choosing the starting municipality at random when the cluster is the union of two or more clusters (municipalities).
- Collecting and analysing water samples and sanitary inspections five days per week (Monday through Friday), instead of the four days per week recommended by the international consultant.
- Dedicating personnel to process the microbiological samples.
- Assigning personnel from those collecting samples and carrying out sanitary inspections to process arsenic tests. Other personnel were assigned to process the other chemical tests.
- Processing faecal streptococci samples on Thursdays and reading the results on Saturdays.

The water supplies were located by laying out routes on maps, and by using local information collected by hygiene extension workers. Municipal personnel also acted as local guides. The final workplan is shown in Figure 2.4 and in Annex 3. Field guides were provided for each of the RADWQ parameters selected for analysis, which explained how to process the water samples. The regional offices of ENACAL and the departmental offices of MINSA provided transportation for sample collection and sanitary inspection. The field work was closely watched by supervisors, to provide quality assurance for the data. The final data were entered into the database by employees at CIEMA-UNI, using the SanMan software program provided by the Water, Engineering and Development Centre, Loughborough University, UK.

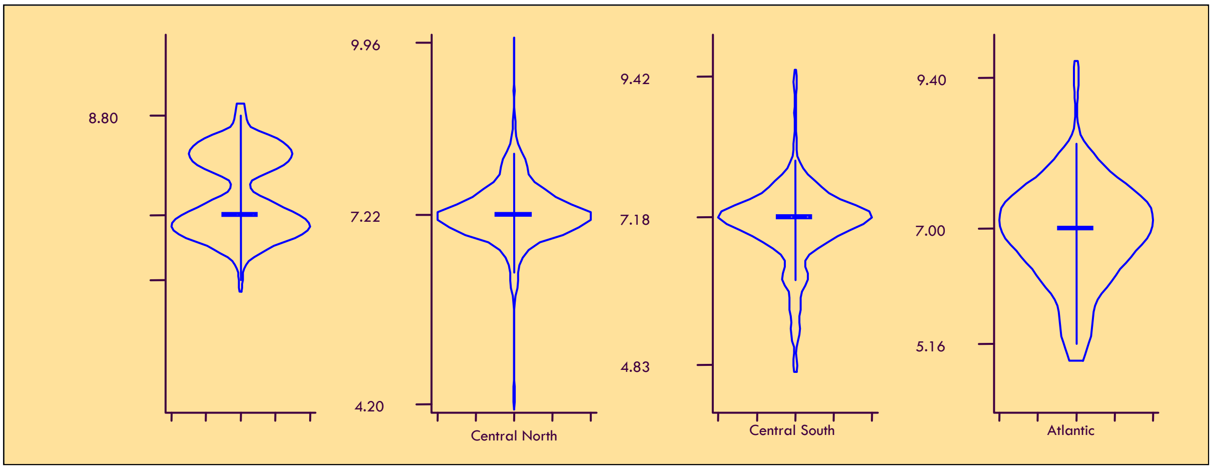
3. Results

3.1 Physical and chemical parameters

pH

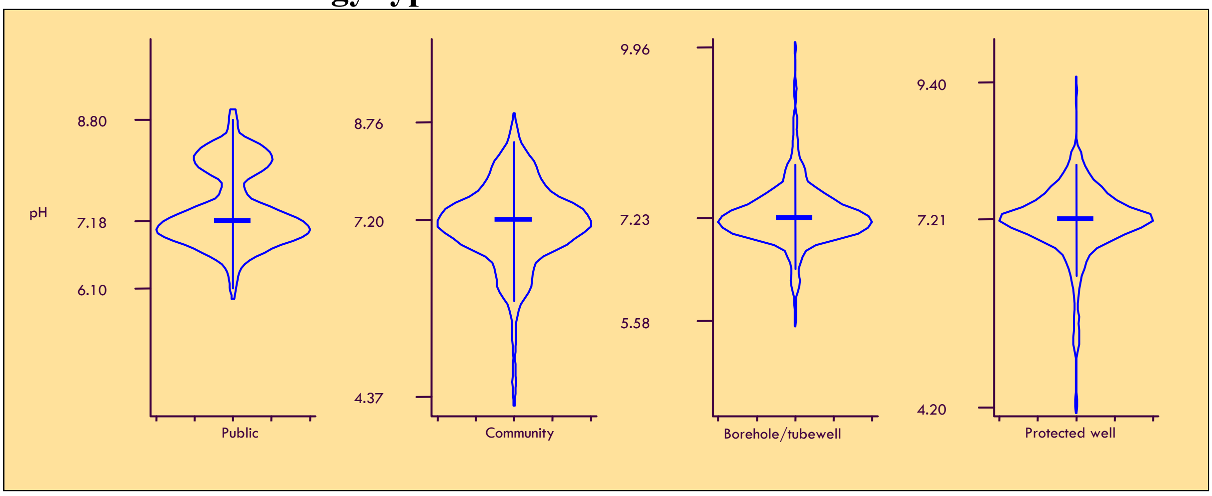
The distribution of pH values for the assessed water supplies is shown in Figure 3.1 for each of the four broad areas. Samples from the Pacific broad area showed a bimodal distribution of values concentrated around pH 7.0 and 8.2, with minimum and maximum values not very different from the mean. This is in contrast to the pH distributions seen for water samples from the three other broad areas (particularly the Central North broad area), where pH values ranged from 4.2 to almost 10.0. These findings are worth confirming, but the results are *prima facie* evidence that the water sources in these areas warrant continuous monitoring.

Figure 3.1 **Distribution of pH values for assessed water samples, by broad area**[a]



[a] The figures show the minima, means and maxima for pH values. The distribution of the pH values for each broad area is represented by the curves.

Figure 3.2 **Distribution of pH values for assessed water supplies, by technology type**[a]



[a] The figures show the minima, means and maxima for pH values. The distribution of the pH values for each technology type is represented by the curves.

When the water samples were disaggregated by technology type, extreme pH values were seen for all types, with the exception of public piped water supplies (Figure 3.2). Most of the extreme low pH values were detected in samples from tubewells and protected dug wells of the Central North area.

Acidic water is also a concern because the toxicity of certain metals, such as aluminium, increases at low pH. By contrast, in the Pacific broad area, 37% of the water samples from public piped water supplies had a pH >8. This is a cause for concern because although the piped water supplies were supposed to be chlorinated regularly, chlorination is less effective when the water pH >8, which increases the health risk from pathogens.

Turbidity

The turbidity of the water samples was also measured because this parameter is important, not only in determining the aesthetic acceptability of the water by the consumer, but also because high turbidity reduces the effectiveness of disinfection by chlorine, thereby increasing the health risk to the consumer. For effective disinfection of individual water supplies WHO recommends that the turbidity be <1 NTU (WHO, 1997), and <5 NTU to disinfect a water-supply system. In Nicaragua, RADWQ survey found that 8.3% of the community supplies and 9.1% of protected wells had turbidity levels >5 NTU (Table 3.1). Median values for the turbidity of the assessed water supplies are given in Table 3.2 for each of the broad areas, by technology type. The distributions of the turbidity values are also shown by broad area (Figure 3.3) and by technology type (Figure 3.4). In most cases, the turbidity values were approximately 1 NTU, with some extreme values in the Central North area (municipality of Estelí and Somoto, in the department of Madriz) that corresponded to boreholes and protected wells.

Table 3.1 **Percentage of water supplies with turbidity values greater than 5 NTU, by broad area and technology**[a]

Broad area	Technology				Broad area % for all technologies
	Public	Community	Borehole/ tubewell	Protected well	
Pacific	0.0	n/a	n/a	n/a	0.0
Central North	0.0	11.4	5.6	8.9	7.6
Central South	6.9	0.0	1.5	2.9	2.1
Atlantic	0.0	0.0	0.0	15.9	13.8
Technology % for all broad areas	0.6	8.3	5.1	9.1	5.9

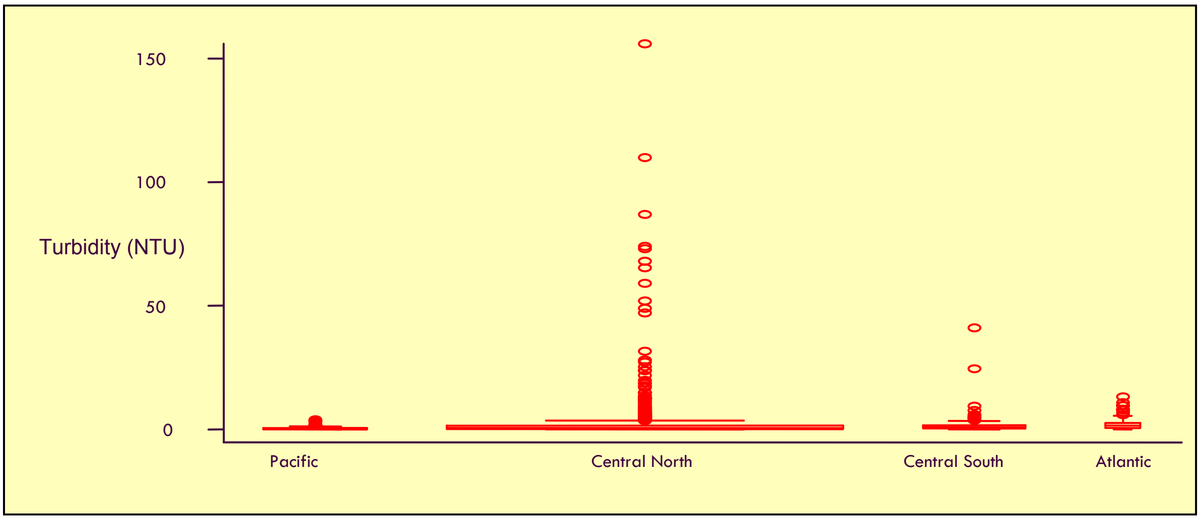
[a] n/a = not applicable; the water-supply technology was not assessed.

Table 3.2 **Median turbidity values of Nicaraguan water supplies, by broad area and technology type**[a]

Broad area	Public piped supply	Community	Borehole/ tubewell	Protected well	Broad area median values
Pacific	0.16	n/a	n/a	n/a	0.16
Central North	0.25	1.21	0.48	0.66	0.61
Central South	1.54	1.10	0.80	0.78	0.96
Atlantic	1.98	0.15	n/a	1.36	1.43
Median turbidity values by technology type	0.25	1.15	0.58	0.79	0.58

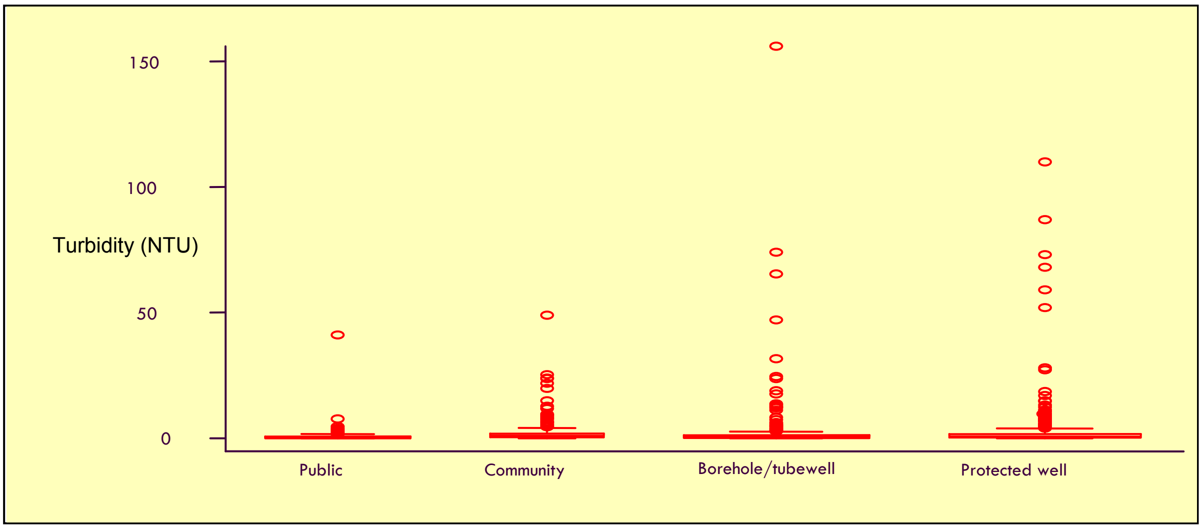
[a] The median turbidity value is equivalent to the 50th percentile. Turbidity values are given in NTU. n/a = not applicable; the water-supply technology was not assessed.

Figure 3.3 **Distribution of turbidity values, by broad area**[a]



[a] The number of samples for a given turbidity value is indicated by the horizontal spread of the data points.

Figure 3.4 **Distribution of turbidity values, by technology type**[a]

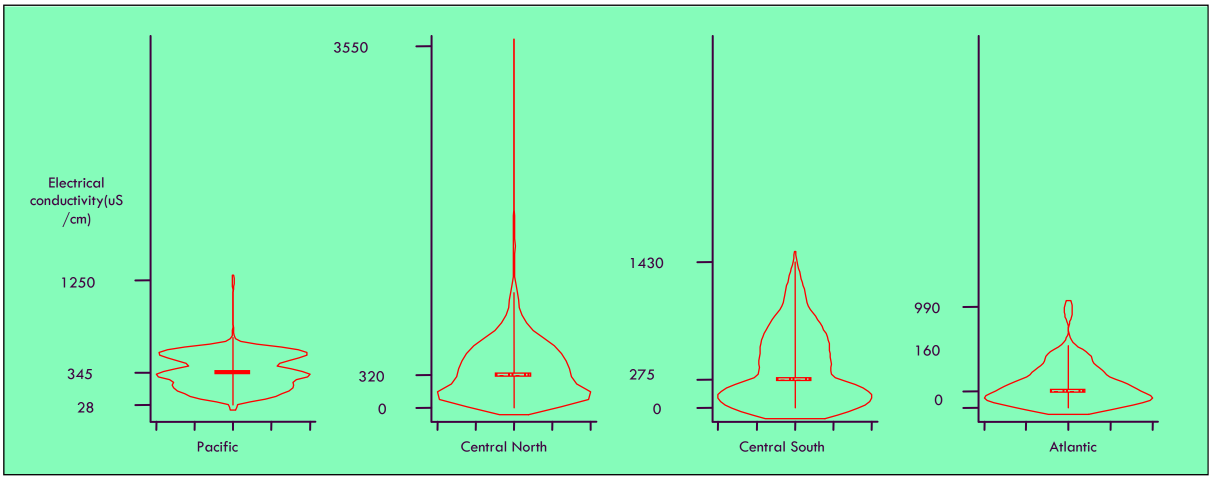


[a] The number of samples for a given turbidity value is indicated by the horizontal spread of the data points.

Electrical conductivity
The electrical conductivity of water is used as an indirect measure of the concentration of dissolved solids, which can affect the flavour and salinity of the water. Distilled water has a conductivity of <0.3 µS/cm, whereas water with a total dissolved solids concentration of 1000 mg/l has a conductivity of 1400 µS/cm. Any water sample with a conductivity >500 µS/cm indicates contamination. Electrical conductivity is important because it allows guidelines to be established for water that make it acceptable to users. Also, any increase in the electrical conductivity value of a water source over time can indicate that the water source has become contaminated (e.g. by fecal coliforms, natural or anthropogenic sources of minerals).

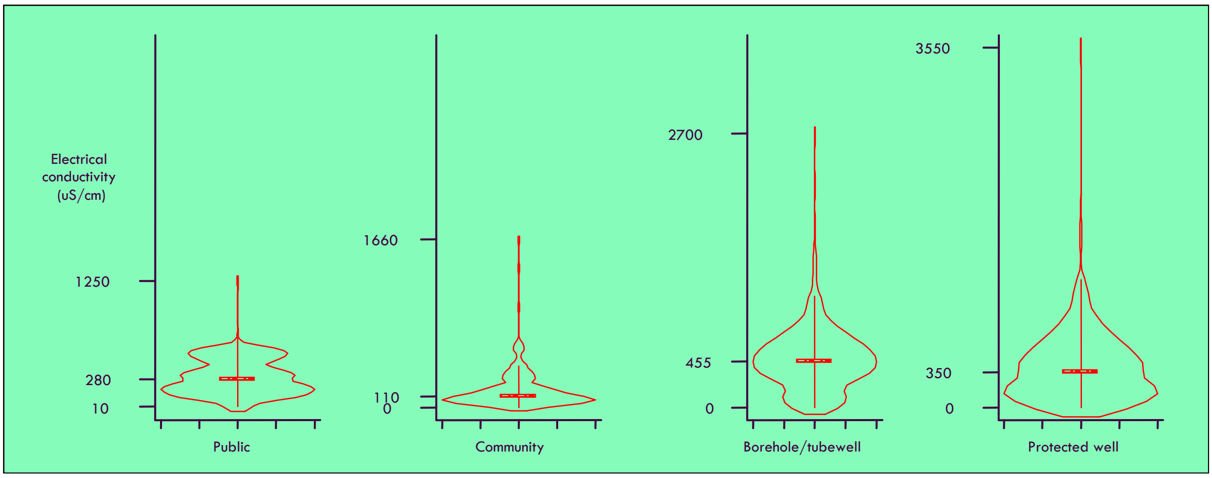
Most of the water supplies assessed by the RADWQ survey had electrical conductivity values <500 µS/cm, but water supplies in the Central North broad area (Figure 3.5) and protected wells (Figure 3.6) had values as high as 3550 µS/cm. The Central North broad area, and protected wells and boreholes also had extreme values for pH (Figures 3.1, 3.2) and turbidity (Figures 3.3, 3.4). By contrast, the departments of Chontales and Granada were exceptional for their low median values and narrow ranges for conductivity. A summary of the median values and ranges for pH, turbidity and electrical conductivity are given for each department in Table 3.3.

Figure 3.5 **Distribution of electrical conductivity values, by broad area**[a]



[a] The figures show the minima, means and maxima for electrical conductivity values. The distribution of the values for each broad area is represented by the curves.

Figure 3.6 **Distribution of electrical conductivity values, by technology type**[a]



[a] The figures show the minima, means and maxima for electrical conductivity values. The distribution of the values for each technology type is represented by the curves.

Free and total chlorine

Disinfection of water supplies for human consumption is an important factor in the fight against waterborne diseases. Although a broad range of disinfectants are available, in Nicaragua chlorine is the main disinfectant used for water supplies other than bottled water. Chlorine has many advantages: It is cheap, effective, easy to measure and persists in residual form, preventing recontamination. In Nicaragua, free or residual chlorine levels in the range 0.5–5.0 mg/l are considered to be acceptable. The absence of residual chlorine in the water of a distribution system raises the risk that the water supply could become contaminated with pathogens subsequent to the initial treatment with chlorine. In tropical climates this is a particular concern, because chlorine levels can decrease rapidly in the high ambient temperatures. For this reason, in the RADWQ survey for Nicaragua, chlorine levels were measured immediately after obtaining the water sample. Residual chlorine can also combine with organic products during decomposition and form trihalomethanes, which are carcinogenic compounds that can persist in the water supplies.

The RADWQ survey found that disinfection with chlorine was mainly used in public piped water supplies. Chlorine use was rare with other technologies, or the amount administered was below detection level. The medians and ranges for residual (free) and total chlorine levels are given in Table 3.4, by technology type. Over one third (36%) of the public piped water supplies had residual chlorine levels <0.5 mg/l, which is inadequate for effective disinfection, and over 97% of the samples from the other technologies had even lower residual chlorine concentrations. The only borehole sample where chlorine was detected showed equal concentrations of free and total chlorine, which could indicate a measuring error.

Table 3.3 **Medians and ranges for pH, electrical conductivity and turbidity, by department**

Department	pH		Conductivity		Turbidity	
	Median	Range	Median	Range	Median	Range
Boaco	7.3	5.8–9.4	600	60–1430	0.63	0–175
Chontales	6.9	4.8–7.8	80	0–330	1.21	0–41
Estelí	7.1	4.2–9.2	370	10–2700	0.37	0–156
Granada	6.9	6.2–7.7	160	28–320	0.16	0–4
Jinotega	7.2	5.9–8.8	90	0–1370	1.54	0–24
Madriz	7.5	6.6–8.6	80	0–1100	0.05	0–110
Managua	8.1	7.0–8.8	260	130–1250	0.31	0–2
Masaya	8.2	8.0–8.3	380	320–690	0.40	0–4
Matagalpa	7.2	4.4–10.0	390	0–3550	0.97	0–74
Nueva Segovia	7.4	6.7–8.8	310	0–1520	0.85	0–19
Río San Juan	7.1	5.7–7.8	80	40–1000	1.18	0–5
Rivas	7.2	7.0–7.5	530	30–570	0.00	0–1
RAAN	7.0	5.2–9.4	160	0–990	1.42	0–13
All departments, by parameter	7.2	4.2–10.0	320	0–3550	0.58	0–175
Total samples all departments, by parameter	1471		1469		1471	

Arsenic

Arsenic is a naturally occurring element that has long been recognized as a poison, and much attention has focused on this metal since the 1990s, when high concentrations were detected in borehole water in Bangladesh. In humans, poisoning is frequently associated with the ingestion of contaminated food, such as seafood, rather than with water consumption. Approximately 93% of all cases of arsenic ingestion occur via foodstuffs, but because the arsenic in food is predominantly in organic form it is of low toxicity. On the contrary, arsenic in drinking-water is in inorganic form and poses an important threat to human health. Arsenic accumulates in humans and chronic exposure is associated with diseases of the skin and cancer.

Table 3.4 Medians and ranges for free and total chlorine levels in Nicaraguan water sources, by technology type

Technology type	Free chlorine (mg/l)		Total chlorine (mg/l)	
	Median	Range	Median	Range
Public	0.6	0.0–3.0	0.5	0.0–6.0
Community	0.0	0.0–2.0	0.0	0.0–2.5
Boreholes/tubewells	0.0	0.0–0.5	0.0	0.0–0.5
Protected wells	0.0	0.0	0.0	0.0
National	0.0	0.0–3.0	0.0	0.0–6.0
Total samples	1153		1152	

There is no consensus on the definition of arsenic poisoning, and high concentrations of arsenic in the water supplies of a community are not necessarily associated with symptoms of poisoning, but many studies suggest that malnutrition and hepatitis B, conditions found commonly in Nicaragua, accentuate the effects of arsenic ingestion. The first documented case of arsenic poisoning in Nicaragua was in 1996, in the extreme south of Matagalpa department. Since then, several assessments have confirmed the presence of high levels of arsenic in several areas of the country (PIDMA-UNI, 2001, 2002a,b; INETER-COSUDE, 2004; UNICEF-ASDI, 2004).

The RADWQ survey in Nicaragua found that most water sources in Nicaragua were in compliance with the WHO guideline value for arsenic and few had levels above 0.01 mg/l (Table 3.5). None of the public piped water supplies had arsenic levels greater than the WHO guideline value. The highest noncompliance rate (8.8%) was recorded for borehole technology in the Central North broad area (Table 3.5), as was the highest arsenic concentration (Table 3.6). By department, the highest noncompliance rates were in Nueva Segovia (8.2%) and Madriz (5.4%), although arsenic was also detected in community water supplies from the departments of Boaco, Estelí, Matagalpa, and RAAN (Table 3.7).

Table 3.5 Percentage of Nicaraguan water samples with arsenic levels exceeding the WHO guideline value of 0.01 mg/l, by broad area and technology[a]

Broad area	Technology				
	Public (%)	Community (%)	Borehole/ tubewell (%)	Protected well (%)	Broad area totals (%)
Pacific	0.0	n/a	n/a	n/a	0.0
Central North	0.0	0.5	8.8	4.0	4.9
Central South	0.0	0.0	4.3	1.7	1.8
Atlantic	0.0	0.0	0.0	1.4	1.3
Totals	0.0	0.4	8.1	3.3	3.5

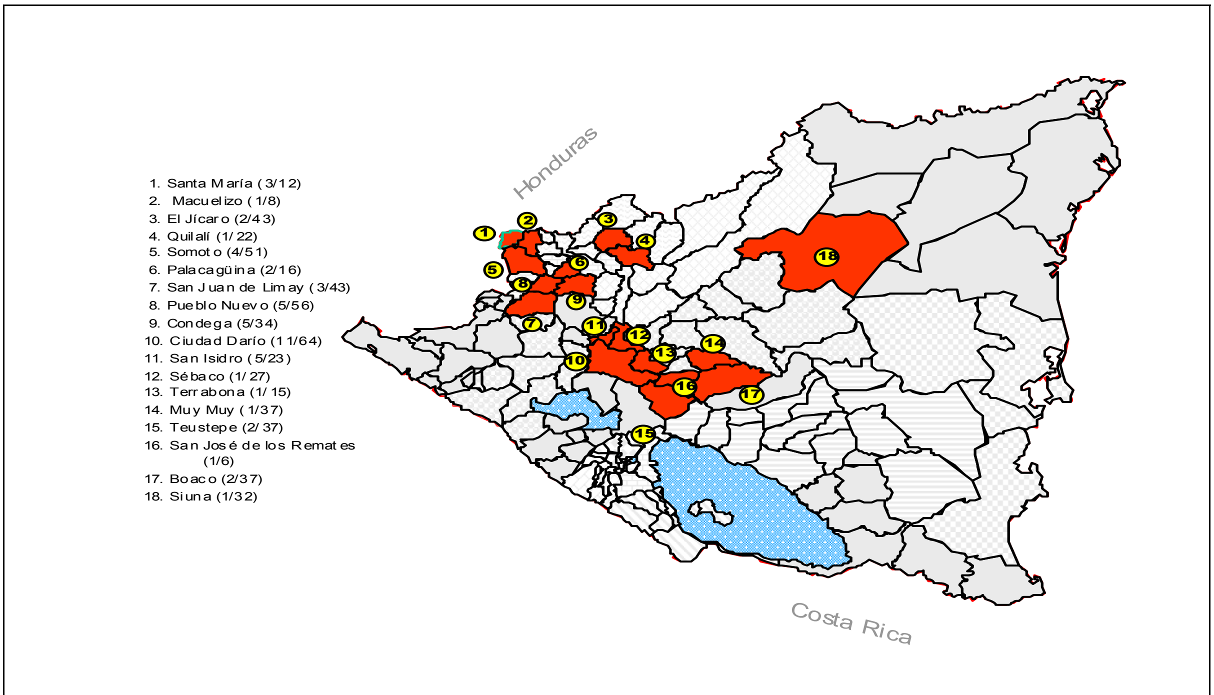
[a] n/a = not applicable; the water-supply technology was not assessed.

Table 3.6 **Median values and ranges of arsenic concentrations for Nicaraguan water supplies, by broad area and technology**[a]

Broad area	Public		Community		Borehole/tubewell		Protected well	
	Median (mg/l)	**Range** (mg/l)	**Median** (mg/l)	**Range** (mg/l)	**Median** (mg/l)	**Range** (mg/l)	**Median** (mg/l)	**Range** (mg/l)
Pacific	0.0	0.0–0.003	n/a	n/a	n/a	n/a	n/a	n/a
Central North	0.0	0.0–0.005	0.0	0.0–0.041	0.0	0.0–0.161	0.0	0.0–0.078
Central South	0.0	0.0	0.0	0.0–0.005	0.0	0.0–0.004	0.0	0.0
Atlantic	0.0	0.0	0.0	0.0–0.0	n/a	n/a	0.0	0.0–0.029

[a] The highest levels of arsenic were found in water supplies in La Grecia, department of Estelí (0.161 mg/l); and in Vigia Sur (0.078 mg/l) and Santa María (0.055 mg/l), department of North Segovia. n/a = not applicable; this technology type was not assessed for the broad area.

Figure 3.7 **Location of municipalities with arsenic concentrations exceeding the WHO guideline value of 0.01 mg/l**[a]



[a] The figures following municipality names indicate the number of water sources with arsenic levels exceeding the WHO guideline value (0.01 mg/l), out of the total number of water sources tested.

The RADWQ survey results show that arsenic contamination of water supplies is more widespread than has been assumed over the previous two decades. Of 46 municipalities evaluated in the Nicaragua RADWQ survey, 18 had water sources with total arsenic levels above the WHO guideline value of 0.01 mg/l. They are mostly located in the Central North broad area (Figure 3.7). These results are generally consistent with earlier studies. In 2001, a survey of 124 Nicaraguan water supplies (50 boreholes and 74 dug wells) found that four boreholes and two dug wells had arsenic levels above the WHO guideline value of 0.01 mg/l (PIDMA-UNI, 2001). Similarly, another national study of 106 water-supply systems (22 tubewells, 62 protected dug wells and 22 springs) found that three tubewells (13.6% of all tubewells tested) and three protected dug wells (4.8% of total protected wells tested) had arsenic concentrations greater than 0.01 mg/l (PIDMA-UNI, 2002a). Even though the sample size and survey designs were different from the RADWQ survey for Nicaragua,

Table 3.7 **Noncompliance of Nicaraguan water samples with WHO guideline values for As, Fe, F and Cu, by department**

Department	Water samples exceeding WHO standards							
	Arsenic >0.01 mg/l		Iron >0.3 mg/l		Fluoride >1.5 mg/l		Copper >2 mg/l	
	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)
Boaco	4/117	3.4	13/119	10.9	3/119	2.5		
Chontales	0/60	0.0	2/60	3.3	1/60	1.7	0/26	0.0
Esteli	13/332	3.9	35/260	13.5	0/330	0.3		
Granada	0/65	0.0	19/65	29.2	5/65	7.7	0/7	0.0
Jinotega	0/50	0.0	2/50	4.0	0/50	0.0		
Madriz	6/112	5.4	16/112	14.3	2/112	1.8	0/1	0.0
Managua	0/43	0.0	1/43	2.3	0/42	0.0		
Masaya	0/65	0.0	4/65	6.1	0/64	0.0		
Matagalpa	19/334	5.7	17/235	7.2	2/334	0.6		
Nueva Segovia	7/85	8.2	10/84	11.9	0/84	0.0		
Río San Juan	0/41	0.0	1/41	2.4	0/41	0.0	0/10	0.0
Rivas	0/65	0.0	11/65	16.9	0/65	0.0		
RAAN	1/80	1.3	0/53	0.0	0/80	0.0		
Totals	50/1449	3.5	131/1252	10.5	13/1446	0.9	0/44[a]	0.0

[a] Only 44 samples were analysed for copper, in water supplies where pipes were made of this material.

Table 3.8 **Noncompliance of Nicaraguan water supplies in surveys of arsenic levels**[a]

Survey	Boreholes/tubewells		Dug wells (protected)	
	(*n*)	(%)	(*n*)	(%)
PIDMA-UNI (2001)	50	8.0	74	2.7
PIDMA-UNI (2002a)	22	13.6	62	4.8
JMP RADWQ in 2004	422	8.3	446	3.1

[a] Noncompliance was measured against the WHO guideline value of 0.01 mg/l.

the noncompliance rates calculated by the three surveys are remarkably similar (Table 3.8), as are the distributions of arsenic concentrations in the water supplies (Table 3.9).

Iron

Iron is one of the most common elements and forms approximately 5% of the earth's crust. Rainwater dissolves the iron in the crust and carries it to almost all types of natural water supplies. Although iron is not considered to pose a health hazard *per se,* it can stain clothes and impart a penetrating odour to water, which can cause users to reject a water source in favour of other, possibly less safe, water supplies. For this reason, the WHO guideline value for iron (0.3 mg/l) is based on the flavour and appearance of drinking-water, rather than on negative health effects.

Nationally, 10.5% of the water sources tested had iron concentrations exceeding the WHO guideline value (Table 3.10) and this correlated with high levels of user dissatisfaction found by the field teams. The highest levels of noncompliance with the WHO guideline value were found in the cities of Diriá and Diriomo in the department of Granada, where 30% of the water supplies had iron levels exceeding 0.3 mg/l (Table 3.7). This result needs to be confirmed, given the extent of the problem suggested by the RADWQ survey.

Table 3.9 Distribution of arsenic concentrations in surveys of Nicaraguan water sources[a]

Survey	Arsenic concentrations in water sources							
	≤0.005 mg/l		>0.005–0.010 mg/l		>0.010–0.020 mg/l		>0.020 mg/l	
	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)
PIDMA-UNI (2001)	88	71.0	30	24.0	4	3.2	2	1.6
PIDMA-UNI (2002a)	87	82.0	13	12.0	4	3.7	2	1.9
JMP RADWQ in 2004	1117	91.2	67	5.5	20	1.6	20	1.6

[a] Only arsenic concentrations measured with a digitial arsenator are shown for the RADWQ survey, which amounted to 1224 samples.

Table 3.10 Noncompliance of Nicaraguan water sources with the WHO guideline value for iron, by broad area and technology[a]

Broad area	Public (%)	Community (%)	Borehole/ tubewell (%)	Protected well (%)	Broad area means for all technologies (%)
Pacific	14.7	n/a	n/a	n/a	14.7
Central North	0.0	7.3	14.9	11.5	10.8
Central South	3.4	1.6	13.0	8.2	7.3
Atlantic	0.0	0.0	n/a	n/a	0.0
Technology means for all broad areas	10.8	5.9	14.6	9.3	10.5[b]

[a] n/a = not applicable; this technology type was not assessed for the broad area.

[b] This figure represents the national average noncompliance rate (%) for all technology types.

Fluoride

Research indicates that 1 mg/l of fluoride in water reduces dental decay, whereas concentrations greater than 2 mg/l lead to dental fluorosis. Recent evidence also suggests that fluoride in drinking-water increases the toxicity of aluminium (used as a clarifier in many water-processing systems), which is of particular concern given the number of aluminium utensils that are used for cooking and to boil water.

In the RADWQ survey for Nicaragua, fluoride was detected in 97% of the water samples tested, with a median concentration below 1 mg/l for all broad areas and technologies (Table 3.11). Fluoride concentrations exceeded the WHO guideline value of 1.5 mg/l in only 0.9% (13 supplies, located in nine municipalities) of the water samples tested (Table 3.7). The highest fluoride concentration detected (1.7 mg/l), and the greatest proportion of water supplies exceeding the WHO guideline value for fluoride (7.7%), were both recorded in the department of Granada. Nationally, the median fluoride concentration for public piped-water supplies was 0.6 mg/l, which provide water to approximately 60% of the Nicaraguan population (Table 3.11).

Table 3.11 **Median fluoride concentrations for Nicaraguan water sources, by broad area and technology**

Broad area	Public (mg/l)	Community (mg/l)	Borehole/ tubewell (mg/l)	Protected well (mg/l)	Broad area medians for all technologies (mg/l)
Pacific	0.60	n/a	n/a	n/a	0.60
Central North	0.60	0.30	0.55	0.55	0.50
Central South	0.50	0.35	0.65	0.50	0.40
Atlantic	0.23	0.75	n/a	0.55	0.50
Technology median values for all broad areas	0.60	0.30	0.55	0.55	0.55[b]

[a] n/a = not applicable; this technology type was not assessed for the broad area.

[b] This figure represents the national median fluoride concentration (mg/l) for all technology types.

The locations of the municipalities in which fluoride was detected in the water sources are shown in Figure 3.8, together with the levels of fluoride measured. The fluoride level for a municipality was determined by the highest fluoride level measured in the municipality, even if the majority of fluoride measurements were lower. For example, if one water sample had a fluoride concentration of 1.3 mg/l and nine others from the same municipality all had concentrations below 1 mg/l, the municipality was placed in the 1–1.5 mg/l category.

In 1999, WHO conducted an assessment of fluoride levels in Nicaraguan natural water supplies (WHO-MINSA, 1999). The national survey examined 514 water supplies in communities with 2000 or more inhabitants, and found that 82% of the samples (in 233 localities) had low fluoride concentrations (0–0.5 mg/l), 12% had optimal concentrations (>0.5–1.0 mg/l), and 2.0% had concentrations above 1.5 mg/l (Table 3.12). Fluoride levels were also found to be optimal (>0.5–1.0 mg/l) in water supplies in the department of Managua, with the exception of localities north of Managua city. These levels are considered to be adequate to protect against dental decay for the 25% of the total population living in this department.

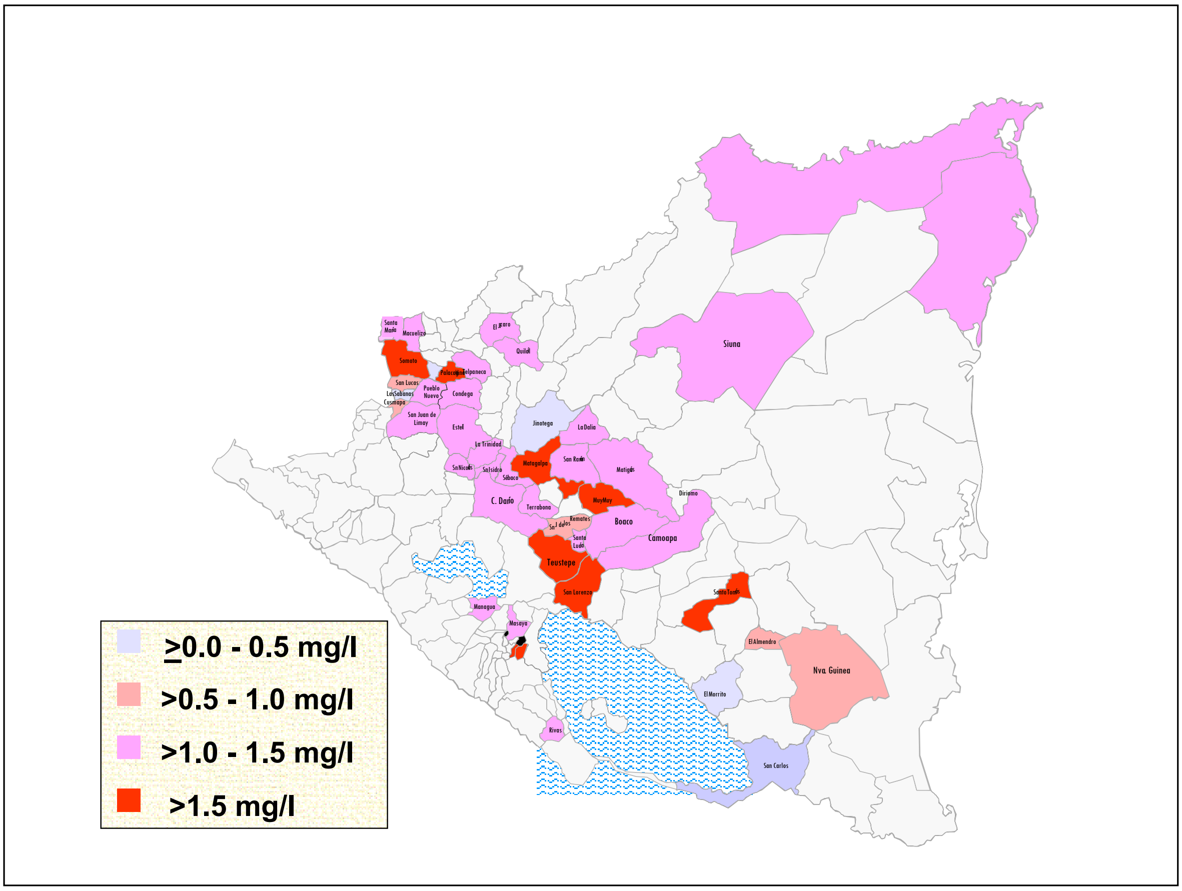
Table 3.12 **Fluoride concentrations in surveys of Nicaraguan water sources**

Fluoride concentration ranges									
0–0.5 mg/l		>0.5–1.0 mg/l		>1.0–1.5 mg/l		>1.5–2.0 mg/l		>2.0–3.0 mg/l	
(*n*)	(%)	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)	(*n*)	(%)
600[a]	41.5	643	44.5	190	13.1	13	0.9	0	0.0
421[b]	81.9	62	12.0	21	4.1	7	1.4	3	0.6

[a] Data from RADWQ survey for Nicaragua.
[b] Data from WHO/MINSA (1999)

The RADWQ survey results show that since the 1999 WHO-MINSA study the proportion of water supplies with optimal fluoride levels has more than tripled (from 12.0% to 44.5%, Table 3.12). However, the situation should be carefully monitored, because high levels of fluoride are already added to many products for human consumption in Nicaragua (e.g. instant tea, salt, flour, sodas), which could increase the level of fluoride consumed to, or above, the WHO guideline value in a significant proportion of the population.

Figure 3.8 **Location of municipalities where the RADWQ survey detected fluoride in water supplies**



Copper

Copper is necessary for good health and the daily human requirement is assumed to be approximately 1 mg. Copper is normally found in very low concentrations in natural water sources and usually supplies approximately 5% of daily needs. In higher doses, however, copper can be harmful and cause vomiting, diarrhoea and nausea. If water containing copper concentrations greater than 1 mg/l is ingested for longer than 14 days this can lead to renal and hepatic damage (Baker et al., 1995; Barceloux, 1999). In the RADWQ survey for Nicaragua, water samples were tested for copper only when water pipes were made of the material, and in none of the 44 samples processed was the copper concentration greater than the WHO guideline value of 2.0 mg/l (Table 3.7). Indeed, the highest copper concentration measured was 0.10 mg/l.

Nitrates

Although nitrates can be present in groundwater and food, in most cases the concentrations are innocuous. High concentrations of nitrogen in water sources usually result from human activities, such as from the use of fertilizers, or from contamination by garbage or sewage. High nitrate concentrations in the body disrupt the ability of blood to transport oxygen, which can lead to methaemoglobinaemia (blue baby syndrome). The WHO guideline value for nitrate is 50 mg/l (as NO_3). Because of a miscommunication, only 895 of the 1488 total samples were assessed for nitrates, but none had nitrate concentrations exceeding the WHO guideline value (Table 3.13).

Table 3.13 **Median and maximum nitrate concentrations, by broad area and technology**

Broad area	Public		Community		Borehole/tubewell		Protected well	
	Median (mg/l)	Max. (mg/l)	Median (mg/l)	Max. (mg/l)	Median (mg/l)	Max. (mg/l)	Median (mg/l)	Max. (mg/l)
Pacific								
Central North	0.26	5.00	0.79	16.46	1.23	6.29	1.06	4.40
Central South	0.33	0.66	0.53	2.59	0.97	8.36	1.06	4.40
Atlantic	0.75	1.54	3.08	3.08			1.10	4.40
Nitrate concentrations, by technology type	0.35	5.00	0.62	16.46	1.23	8.36	1.06	4.40

3.2 Microbiological parameters

The most common health risk associated with drinking-water comes from faecal contamination, and for this reason microbiological analyses of drinking-water quantify microorganisms that could indicate such contamination. At a practical level, it would not be financially feasible to test for all possible pathogens, and instead one or more indicator organisms are used to monitor the microbiological quality of drinking-water. In the RADWQ survey for Nicaragua, thermotolerant coliforms and faecal streptococci were used as the indicator organisms for testing water sources, and household water samples were tested only for streptococci. It should be noted that the presence of these microorganisms does not guarantee that the water source is unsafe, because many coliform species are nonpathogenic, but their presence indicates that the water source is likely contaminated.

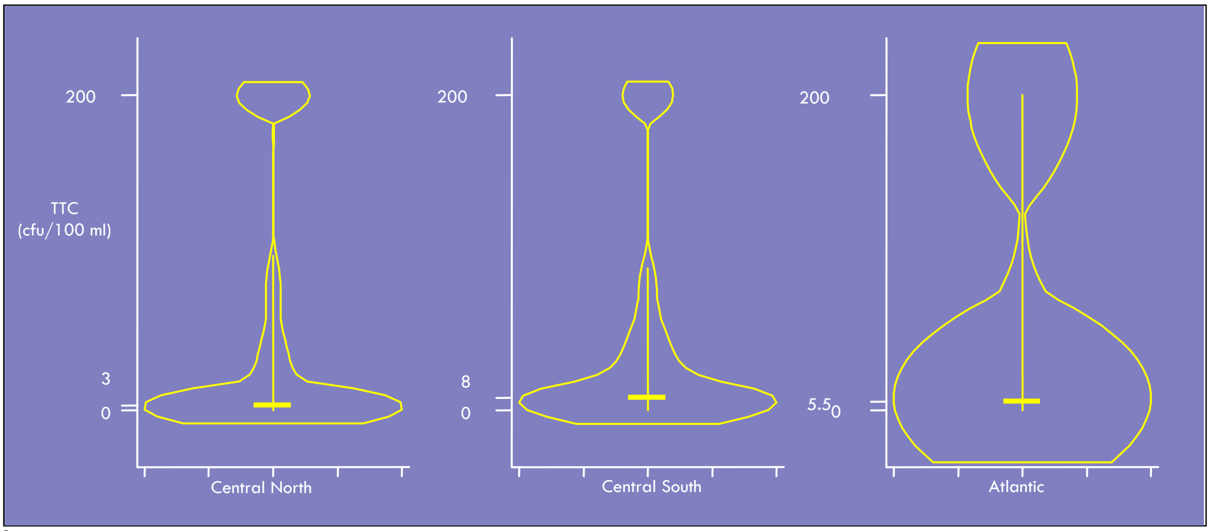
The RADWQ survey results show that most of the evaluated water sources in Nicaragua were contaminated with faecal coliforms (Table 3.14), with water supplies in 42 municipalities (out of a total of 46 evaluated) testing positive for thermotolerant coliforms. Faecal contamination was particularly widespread for protected dug wells in the Central North (81.5% of wells tested) and Central South (94.2%) broad areas, as well as for community supplies in the Central South (98.6%) and Atlantic (100%) broad areas. The lowest proportion of contaminated water supplies (7.1%) was measured for public piped water supplies in the Pacific broad area, but this was the only technology evaluated for this broad area. The numbers of thermotolerant coliform colonies also varied significantly between samples, as reflected in the median values and ranges of coliform counts for the broad areas and technologies (Table 3.15, Figures 3.9, 3.10).

Overall, the RADWQ results suggest that faecal contamination of water sources is a serious problem in Nicaragua, and that water sources in 90% of the municipalities of the country may be contaminated. This issue is compounded by the finding that 36% of the public piped-water supplies and over 97% of the samples from the other technologies had residual chlorine levels <0.5 mg/l (Table 3.4), which is inadequate for effective disinfection. An analysis of free chlorine levels and thermotolerant coliform counts for public piped water supplies (to which chlorine should be regularly added) found an odds ratio of 3.9 (P <0.001), indicating that water supplies with chlorine concentrations below 0.5 mg/l have a four-fold higher chance of being contaminated with coliforms than those with chlorine levels that meet the WHO guideline value. A similar analysis for turbidity and thermotolerant coliforms found an odds ratio of 2.1 (P = 0.006), indicating that the probability of finding thermotolerant coliforms in water supplies is twice as great if the turbidity is >5 NTU, compared with water sources with a turbidity of less than 5 NTU.

3.3 Sanitary inspections

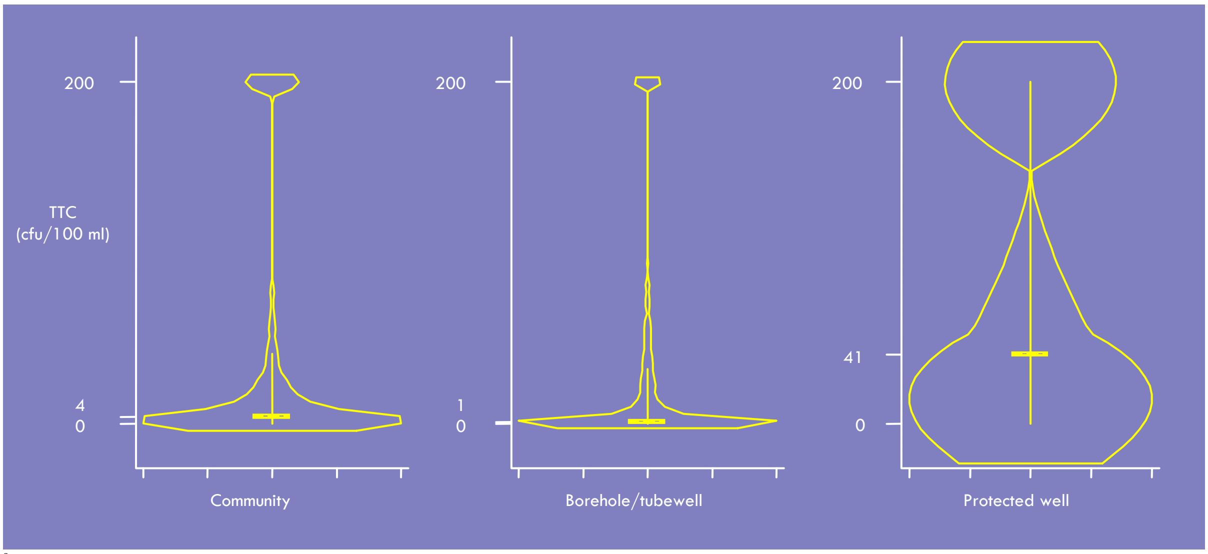
A sanitary inspection in a RADWQ survey is designed to identify conditions or factors that could pose a risk of faecal contamination to the water supply system, and therefore potentially be a danger to human health. A sanitary inspection complements the other analyses of water quality that comprise the RADWQ survey. In the RADWQ survey for Nicaragua, sanitary inspections were made for each water supply that was assessed, following the recommendations specified in the RADWQ draft handbook (Howard, Ince & Smith, 2003), and the resulting sanitary inspection scores were assigned to four levels of risk (Table 3.16). The sanitary inspection scores represent the number of "yes" answers to ten questions, each of which represents a risk factor for water contamination. This means that each risk factor has a value of 10%.

Figure 3.9 **Distribution of thermotolerant coliforms, by broad area**



[a] The figures shows the minima, means and maxima for thermotolerant coliform (TTC) counts (in colony-forming units per 100 ml). The distributions of the TTC counts for each broad area are indicated by the curves.

Figure 3.10 **Distribution of thermotolerant coliforms, by technology**



[a] The figures shows the minima, means and maxima for thermotolerant coliform (TTC) counts (in colony-forming units per 100 ml). The distributions of the TTC counts for each technology type are indicated by the curves.

Table 3.14 **Proportion of Nicaraguan water sources contaminated with thermotolerant coliforms, by broad area and technology**[a]

Broad area	Technology				Mean values for all technology types, by broad area	
	Public (%)	Community (%)	Borehole/tubewell (%)	Protected well (%)		
Pacific	7.1	n/a	n/a	n/a	17/238	7.1
Central North	0.0	46.9	55.0	81.5	537/917	58.6
Central South	55.2	98.6	50.7	94.2	185/237	78.1
Atlantic	9.1	100.0	n/a	63.8	45/80	57.5
Mean values, all broad areas, by technology type	10.1	60.9	54.3	80.7	785/1472[b]	53.3[b]

[a] When the number of thermotolerant coliforms was too large to count, the number was set to 200, rather than report the value as "too large to count", which is the recommended method. n/a = not applicable; the technology type was not assessed for the broad area.

[b] These figures represent national mean values for all technology types.

The distribution of sanitary risk levels for Nicaraguan water supplies are shown for each technology type (Table 3.17) and broad area (Table 3.18). Median sanitary risk scores are shown for all assessed Nicaraguan water supplies by department and technology type in Table 3.19. It is noticeable that many of the water supplies had medium or high sanitary risk levels, even public piped water supplies (44.8% of the public piped water supplies had medium or high risk levels; Table 3.17). Nationally, 15.7% of the water supplies had unacceptable levels of sanitary risk (high and very high risk scores), which indicates that the sanitary integrity of the water supplies is likely in jeopardy. Protected wells from the departments of Río San Juan and Matagalpa also had a 60% sanitary inspection score, which merits immediate action (Table 3.19). Similarly, sanitary inspection scores of 50% were found for community supplies in the departments of Boaco, Jinotega and Matagalpa, as well for public piped-water supplies in Rivas department, which suggests these water supplies need to be carefully monitored.

Table 3.15 **Median values and ranges for thermotolerant coliform counts in Nicaraguan water sources, by broad area and technology**[a]

Broad area	Public		Community		Borehole tubewell		Protected well		Values for all technologies, by broad area	
	Median	Range	Median	Range	Median	Range	Median	Range	Median	Range
Pacific	0	0–70	n/a[b]	n/a	n/a	n/a	n/a	n/a	0	0–70
Central North	0	0–0	0	0–200	1	0–200	45	0–200	3	0–200
Central South	3	0–200	10	0–60	1	0–200	65	0–200	8	0–200
Atlantic	0	0–27	2	0–2	n/a	n/a	16	0–200	6	0–200
Values for all broad areas, by technology	0	0–200	4	0–200	1	0–200	41	0–200	2[c]	0–200[c]

[a] Thermotolerant coliform counts were measured as colony forming units/100 ml.
[b] n/a = not applicable; the corresponding technology was not assessed in the broad area.
[c] These figures represent national values for all technology types.

Table 3.16 **Sanitary inspection scores and risk levels for a RADWQ survey**

Risk level	Sanitary inspection score (%)
Low	0–20
Medium	30–50
High	60–80
Very high	90–100

Table 3.17 **Distribution of sanitary risk levels for Nicaraguan water supplies, by technology type**[a]

Technology	Sanitary risk level			
	Low (%)	Medium (%)	High (%)	Very high (%)
Public	55.2	39.4	5.4	0. 0
Community	16.2	63.4	20.0	0.4
Borehole/tubewell	41.9	42.8	13.1	2.3
Protected well	35.6	43.3	17.7	3.4
National, all technology types	38.4	45.8	14.0	1.7

[a] The figures in the table represent the percentages of the water supplies for a given technology type that were classified into the corresponding sanitary risk level. The percentages were calculated from the totals for each technology type and therefore do not sum to 100% across technology types.

The data in Tables 3.17–3.19 do not identify which risk factors contributed to the sanitary inspection score, although it is possible to group then generally into three categories: potential sources of faecal contamination; potential routes by which polluting agents gain access to water sources; factors that can accelerate contamination. A detailed breakdown of the contributions of different risk factors to the sanitary inspection scores is given in Annex 4 Tables A4.1–A4.4. The data show that potential sources of contamination are associated with most water supplies, and to a lesser extent, factors that facilitate contamination are also present. More of 80% of community water supplies had a latrine within 30 metres of it, for example, or dirt was present around the water supply from where the sample was taken.

Table 3.18 **Distribution of sanitary risk levels for Nicaraguan water supplies, by broad area**[a]

Broad area	Sanitary risk level			
	Low	Medium	High	Very high
Pacific	50.0	44.1	5.9	0.0
Central North	33.5	48.9	15.8	1.7
Central South	35.5	43.8	19.0	3.7
Atlantic	76.2	21.2	1.2	1.2
National, all broad areas	38.4	45.8	14.0	1.7

[a] The figures in the table represent the percentages of the water supplies for a given broad area that were classified into the corresponding sanitary risk level. The percentages were calculated from the totals for each broad area and therefore do not sum to 100% across broad areas.

Table 3.19 **Median sanitary risk scores for Nicaraguan water supplies, by department and technology**[a]

Department	Technology				Median risk score, by department (%)	Number of samples, by department
	Public (%)	Community (%)	Borehole/ tubewell (%)	Protected well (%)		
Boaco		50	30	20	30	123
Chontales	20	35	45	50	35	78
Esteli	5	15	30	30	20	353
Granada	30				30	65
Jinotega		50			50	51
Madriz		30	20	30	30	97
Managua	20				20	43
Masaya	10				10	65
Matagalpa		50	40	60	50	335
Nueva Segovia			40	40	40	92
Rió San Juan		40	20	60	40	41
Rivas	50				50	65
RAAN	10	20		10	10	80
National scores	20	40	30	30	30	1488

[a] The percentage sanitary risk scores and corresponding sanitary risk levels are: 0-20% (low); 30-50 (medium); 60–80% (high); 90–100% (very high).

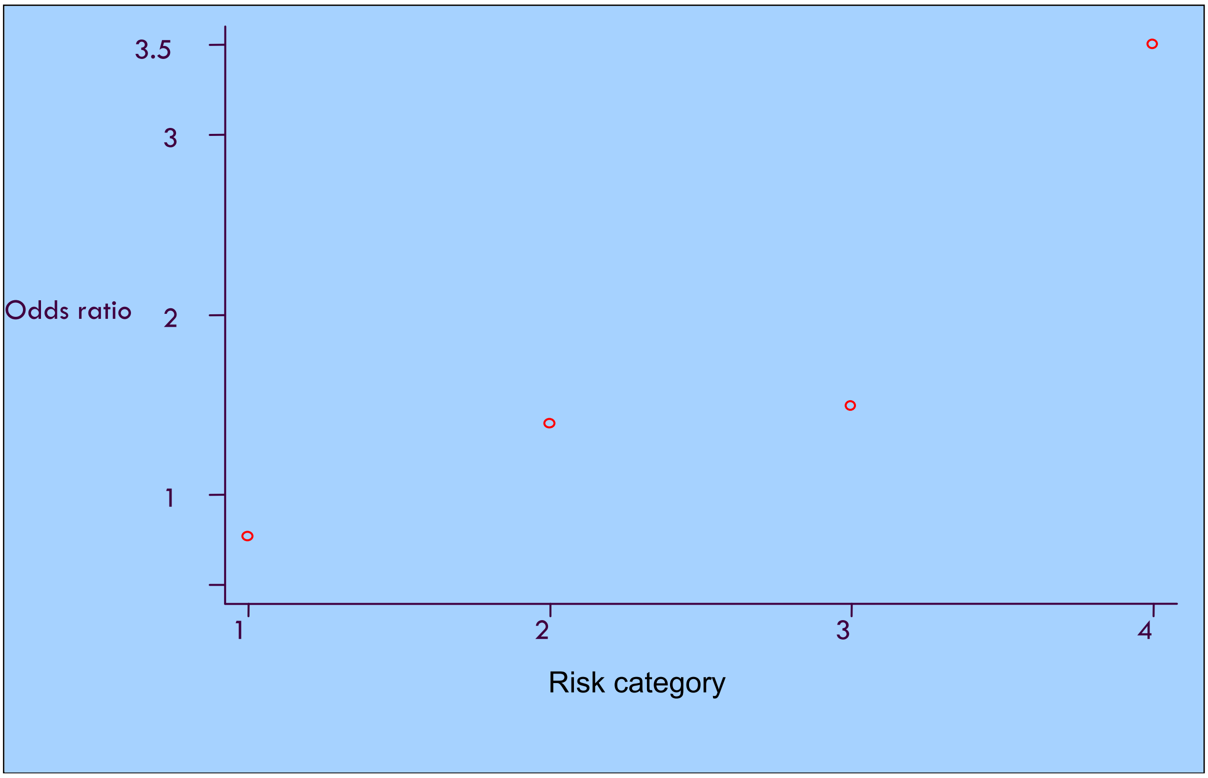
Sanitary risk inspections are important for identifying potential contamination risks associated with thermotolerant coliforms. For this reason, the percentage of samples positive for thermotolerant coliforms are shown for each sanitary risk category by broad area (Table 3.20) and by technology type (Table 3.21). It can be seen that although a higher sanitary risk score is generally associated with a higher proportion of contaminated water supplies, a large proportion of water supplies were positive for thermotolerant coliforms, even though they had a low sanitary risk score. Water supplies from the Central South broad area, for example, were classified as having a low sanitary risk, even though thermotolerant coliforms were detected in nearly 80% of assessed water supplies for the area (Table 3.20). A breakdown of the specific risk factors contributing to the presence (or absence) of thermotolerant coliforms is given in Annex 4 Tables A4.5–A4.7, by technology type.

To examine whether there was an association between the level of sanitary risk and the presence of thermotolerant coliforms, the risk inspection data were analysed by the Mantel-Haenzel statistical test, adjusted by broad area and technology. The results of the analysis show that the odds ratio increased with increasing risk level (Figure 3.11), meaning that the greater the sanitary risk level, the higher the probability of finding thermotolerant coliforms in the water supply.

It is unclear why thermotolerant coliforms were found in many water sources that were classified on the basis of the sanitary risk inspection as having low risk. One possibility is that information was not collected properly; alternatively, the information recorded on the sanitary inspection questionnaire did not accurately reflect the sanitary status of the water supplies. The first explanation is unlikely, because the questionnaire used to collect the sanitary risk information is simple and clear (Annex 2).

The second possibility is more likely, because equal weight is given to each of the risk factors evaluated by the 10 questions of the sanitary inspection questionnaire, but each risk factor may not be

Figure 3.11 **Odds ratios for the presence of thermotolerant coliforms, by sanitary risk level**[a]



[a] Sanitary risk categories: 1 = low; 2 = medium; 3 = high; 4 = very high.

Table 3.20 **Percentage of Nicaraguan water supplies positive for thermotolerant coliforms, by sanitary risk level and broad area**

Sanitary risk level	Broad area			
	Pacific	Central North	Central South	Atlantic
Low	1.7	48.7	79.5	55.7
Medium	13.3	62.6	81.9	64.7
High	7.4	64.4	68.9	0.0
Very high		81.3	66.7	100.0

Table 3.21 **Percentage of Nicaraguan water supplies positive for thermotolerant coliforms, by sanitary risk level and technology type**

Sanitary risk level	Technology			
	Public	Community	Borehole/tubewell	Protected well
Low	8.6	48.8	53.3	73.1
Medium	12.9	62.5	59.1	84.2
High	5.5	65.4	38.6	87.3
Very high	0.0	100.0	60.0	86.7

equivalent in determining the likelihood of faecal contamination. For example, if two water supplies are classified as having a sanitary risk score of 20%, one could have dirt around the water supply, or animals may have access to the area, while the other may have a broken drainage canal or a latrine uphill the supply. The different risk factors may not be equivalent in terms of the likelihood that the water supplies will become contaminated with thermotolerant coliforms. Consistent with this explanation is the observation that a significant proportion of low risk water supplies were positive for risk factor 3 (Tables 3.22–3.24).

Table 3.22 **Percentage of public piped-water supplies and community supplies with low sanitary risk and positive for a sanitary risk factor**[a]

	Risk factor	Public (%)	Community (%)
1.	Do any taps or pipes leak at the sample site?	2.7	16.3
2.	Does water collect around the sample site?	3.2	16.3
3.	Is the area around the tap unsanitary?	16.2	34.9
4.	Is there a sewer or latrine within 30 m of any tap?	10.8	25.6
5.	Has there been discontinuity in the last 10 days?	38.4	20.9
6.	Is the supply main exposed in the sampling area?	7.6	9.3
7.	Have users reported any pipe breaks within the last week?	2.7	2.3
8.	Is the supply tank cracked or leaking?	2.2	0.0
9.	Are the vents and covers on the tank damaged or open?	2.7	0.0
10.	Is the inspection cover or concrete around the cover damaged or corroded?	1.1	2.3

[a] A "yes" response to a question defined "positive" for that risk factor.

Table 3.23 **Percentage of borehole supplies with low sanitary risk and positive for a sanitary risk factor**

	Risk factor	Borehole/tubewell (%)
1.	Is there a latrine within 10 m of the borehole?	9.7
2.	Is there a latrine uphill of the borehole?	4.9
3.	Are there any other sources of pollution within 10 m of the borehole (e.g. animal breeding, cultivation, roads, industry etc)?	40.0
4.	Is the drainage faulty, allowing ponding within 2 m of the borehole?	3.8
5.	Is the drainage channel cracked, broken or in need of cleaning?	8.1
6.	Can animals come within 10 m of the borehole?	40.0
7.	Is the apron less than 2 m in diameter?	11.3
8.	Does spilt water collect in the apron area?	5.4
9.	Is the apron or pump cover cracked or damaged?	2.2
10.	Is the hand pump loose at the point of attachment (or for a rope-washer pump, is the pump cover missing)?	1.6

Table 3.24 **Percentage of protected dug wells with low sanitary risk and positive for a sanitary risk factor**

	Risk factor	Protected well (%)
1.	Is there a latrine within 10 m of the well?	6.9
2.	Is the nearest latrine uphill of the well?	6.3
3.	Are there any other sources of pollution within 10 m of borehole (e.g. animal breeding, cultivation, roads, industry etc.)?	41.5
4.	Is the drainage faulty, allowing ponding within 3 m of the well?	2.5
5.	Is the drainage channel cracked, broken or in need of cleaning?	5.0
6.	Is the cement less than 2 m in diameter around the top of the well?	22.0
7.	Does spilt water collect in the apron area?	15.7
8.	Are there cracks in the cement floor?	6.9
9.	Is the hand pump loose at the point of attachment (or for a rope-washer pump, is the pump cover missing)?	1.3
10.	Is the well cover absent or unsanitary?	7.5

3.4 Household water samples

Water samples were collected from an additional 10% of households in each cluster and the samples analysed for physicochemical and microbiological parameters. The households were selected at random and a total of 145 household samples were collected (Table 3.25). Free chlorine was detected in only 16 of the 145 samples, 15 of them from household water with public piped systems; the other from a household with a water supply administered by the community. The chlorine concentrations in the households supplied by public piped water were all greater than 0.5 mg/l, with a maximum value of 2 mg/l. Elevated iron concentrations (>0.3 mg/l) were also detected in 6.1% of the household samples, the majority from households supplied by a community system. High levels of fluoride (>1.5 mg/l) were found in 1.3% of the samples, all from households with water from protected wells. Arsenic was detected in 9.6% of the 145 household samples (data not shown), and 2.6% of them had concentrations greater than the WHO guideline value of 0.01 mg/l (Table 3.26).

Table 3.25 **Number of household samples, by broad area and technology**[a]

Broad area	Public	Community	Borehole/ tubewell	Protected well	Broad area totals
Pacific	28	n/a	n/a	n/a	28
North	7	21	32	27	87
South	8	5	4	4	21
Atlantic	1	n/a	n/a	8	9
Technology totals	44	26	36	39	145

[a] n/a = not applicable; the technology type was not assessed in the corresponding broad area.

Table 3.26 **Percentages of household water samples with high concentrations of iron, fluoride or arsenic, by broad area and technology**

Broad area	Iron (%)	Fluoride (%)	Arsenic (%)
Pacific	0.0	0.0	0.0
Central North	11.5	3.0	3.0
Central South	7.7	0.0	0.0
Atlantic	0.0	0.0	11.1
Technology			
Public	0.0	0.0	0.0
Community	15.0	0.0	0.0
Borehole/tubewell	0.0	0.0	0.0
Protected well	7.9	4.5	9.1
Mean values for all 145 household samples (%)	6.1	1.3	2.6

The household survey also found that 44.6% of the samples were positive for thermotolerant coliforms, with household samples from community supplies, boreholes/tubewells and protected wells all showing contamination. Samples from protected wells, in particular, had very high concentrations of thermotolerant coliforms (>50 cfu/100 ml). In contrast, thermotolerant coliforms were not found in household water samples supplied by public water-supply systems, but the ineffective levels of residual chlorine (<0.5 mg/l) found in over one third of the piped water systems assessed give cause for concern.

A comparison of the thermotolerant coliform count in household water supplies with the counts found in the corresponding water sources showed that the presence of coliforms in the water sources reflected a fairly high probability of finding coliform contamination in the corresponding household water samples (Table 3.27). Poisson regression analysis of the household data indicated that if a water supply were positive for thermotolerant coliforms, then there was a 58% probability that a household sample would also test positive for these microorganisms, regardless of technology, broad area or sanitary risk.

Faecal streptococci were also detected in 58.7% of household samples (mean value for all technology types). The highest streptococci counts were detected in household samples supplied from tubewells in the Central North and Central South broad areas, with median values of 115 cfu/100 ml and 125 cfu/100 ml, respectively. The frequencies with which thermotolerant coliforms and faecal streptococci were found in household samples are shown in Figure 3.12, according to the technology type that was used to supply the household water. The microbiological analysis of the household samples called attention to three households because of the high levels of coliforms and streptococci. Two were located in El Carrizal, municipality of San Isidro, department of Matagalpa; the other in El Guineo, municipality of Siuna, department of RAAN (Atlantic broad area).

In all of the household samples tested, there was an association between high arsenic concentrations, and the presence of a high number thermotolerant coliforms and faecal streptococci (≥200 cfu/100 ml). This result is sufficiently serious to warrant confirmation by the local authorities, and to initiate corrective action if corroborated. The results of the sanitary inspections, made at the time the household samples were collected, are also surprising, because most of the household samples were assessed as having a low or medium sanitary risk (Table 3.28), but most household samples were found to be contaminated by thermotolerant coliforms or faecal streptococci (Table 3.27; Figure 3.12). Although affirmative answers to questions (risk factors) 3–6 were associated with slightly higher frequencies of microorganisms (Table 3.29), no significant association was found between the level of sanitary risk and the probability of finding microorganisms in the household water supplies. However, it is possible that these risk factors may be the best indicators of microbiological contamination.

Table 3.27 **Percentage of household water samples and corresponding water supplies positive for thermotolerant coliforms, by broad area and technology**

Technology	Water supply (%)	Household sample (%)
Public	10.1	0.0
Community	61.0	57.9
Borehole/tubewell	54.3	36.4
Protected well	80.7	58.8
Broad area		
Pacific	7.1	0.0
Central North	58.6	40.6
Central South	78.1	100.0
Atlantic	57.5	44.4

Table 3.28 **Distribution of household samples by sanitary risk and technology**[a]

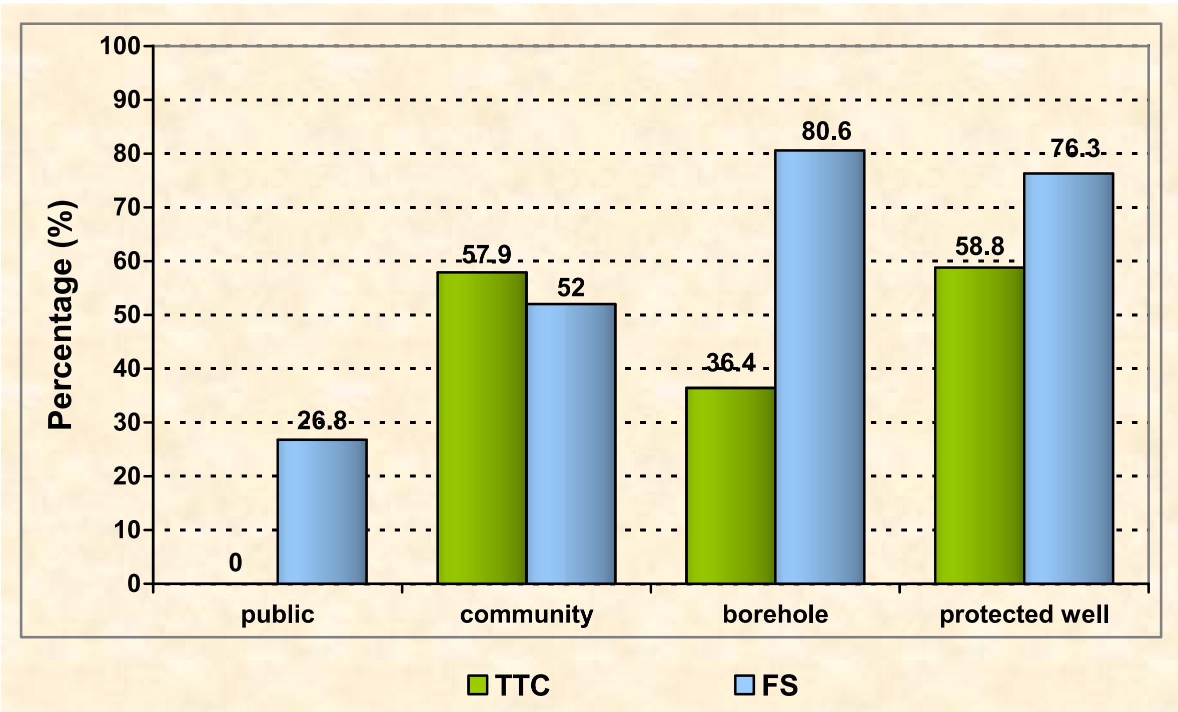
Technology	Sanitary risk level			
	Low (%)	Medium (%)	High (%)	Very high (%)
Public	79.6	18.2	2.3	0.0
Community	46.2	34.6	19.2	0.0
Borehole/tubewell	75.0	22.2	2.8	0.0
Protected well	61.5	35.9	0.0	2.6
Mean values, all technologies	67.6	26.9	4.8	0.7

[a] The figures in the table represent the percentages of the household water supplies for a given technology that were classified into the corresponding sanitary risk level. The percentages were calculated from the totals for each technology and therefore do not sum to 100% across technologies.

Table 3.29 **Percentage of household samples positive for sanitary risk factors and the presence of microorganisms**

Risk factor	Thermotolerant coliforms		Faecal streptococci	
	Absent	Present	Absent	Present
1. Is the water storage container used for storing any other liquid/material?	46.7	36.4	61.4	30.8
2. Is the water storage container kept at ground level?	44.2	46.2	58.9	57.1
3. Is the water storage container lid/cover absent or not in place?	34.3	61.9	57.5	63.0
4. Is the storage container cracked or leaking or insanitary?	38.5	58.8	52.3	80.7
5. Is the area around the storage container insanitary?	35.3	59.1	52.7	70.2
6. Do any animals have access to the area around the storage container?	40.0	56.3	49.4	75.5
7. Is the tap/utensil used to draw water from the container insanitary?	46.3	40.0	58.5	59.9
8. Is the water from the container also used for washing/bathing?	50.0	20.0	59.8	46.1
9. Has there been discontinuity in water supply in the last 10 days?	45.2	42.9	63.9	40.6
10. Is the water obtained from more than one source?	42.6	100.0	58.4	66.7

Figure 3.12 **Percentage of household samples positive for thermotolerant coliforms and faecal streptococci, by technology**[a]



[a] FS = faecal streptococci; TTC = thermotolerant coliforms.

4. Conclusions

The greatest impact of the RADWQ project in Nicaragua has been the increased awareness among field personnel about water quality. Important elements in raising awareness were the facts that personnel worked outside of their usual areas of influence, and that field personnel spent a lot of time in the community, an opportunity that was used to educate the population about water quality. The RADWQ survey for Nicaragua is only the beginning of a more lasting process, with continuing inputs from local staff in charge of water and sanitation. Based on the experience in Nicaragua, two general aspects of the RADWQ method merit comment – the first is related to the implementation of the survey, the second to the results.

Implementation of the RADWQ survey

Although the RADWQ methodology is clear about how to calculate the total number of water samples needed for statistical power, it is less clear about how to stratify the samples to be assessed on the basis of broad area and technology, and about how to choose the location of the water sources and clusters. The process for determining the location and size of clusters follows a somewhat unconventional path, in that the number and size of the clusters are not defined at the beginning of the planning process as usual. Moreover, the sequence for calculating cluster size and location can change arbitrarily during the process.

Such factors are known to affect the statistical power of a study as much as sample size (Levy & Lemeshow, 1999), and it would improve the design of a RADWQ survey if these steps were more clearly defined. It would also be helpful if the RADWQ methodology were more explicit about the interaction of the different parameters. To know, for example, that if cluster size is increased this will not simply affect statistical parameters, such as standard deviation and sample size; it will also increase the time needed to evaluate the water supplies in the cluster. It will also increase other factors, such as the number of communities in the cluster, and the quantities of reagents and supplies needed to assess the cluster.

The sanitary risk assessment needs to be reviewed based on the experiences in Nicaragua, where many water supplies were classified as having a low or medium sanitary risk (Table 3.28), even though thermotolerant coliforms and faecal streptococci were detected in the supplies (Table 3.27). If the sanitary risk inspection is to function as a predictor of the microbial quality of water, the results should follow common sense and a low sanitary risk should indeed be associated with a low probability of fecal contamination.

The SanMan computer software program (version 2.22) was used for data entry. The most noticeable aspects that need to be improved are:

- SanMan needs to be more user friendly. For example, too many steps are needed to enter or edit a single registry entry.
- A great weakness of SanMan is the fact that the data entry fields accept any character type. For easier data analysis and to avoid errors while entering data, these fields need to be numerical only, because non-numerical information (e.g. TNTC) would not then need to be collected or entered. Currently, both numerical and character types are recommended in the RADWQ manual.
- The statistical subroutines do not display the results in a very helpful way. The default report templates are rigid, too simple and they do not allow modifications or complex computations.
- For SanMan to become a more powerful database, future versions need to include a way to create new variables. In version 2.22, for example, there is no field for temperature, nor any way of creating one.

In summary, we feel confident that the Nicaraguan experience with the RADWQ survey will significantly contribute to the optimization and standardization of the method for its application in different localities.

RADWQ survey results

The quality of the work carried out by the field personnel was high, as was all the information collected. We therefore feel confident that the information is representative of what is happening in the areas included in the RADWQ survey. Although the RADWQ survey provided only a "snapshot" of the water and sanitation situation in Nicaragua, and even though the measured parameters can change over time or be influenced by the weather, we nevertheless believe the RADWQ results demonstrate that there is a real problem with the quality of drinking-water in the country. Arsenic contamination of drinking-water supplies may be far more widespread than has been assumed, and most of the water supplies examined were contaminated with faecal coliforms or thermotolerant streptococci. These results will come as no surprise to many, especially those who have investigated the quality of drinking-water from areas known for their high arsenic concentrations. But little is known about the quality of drinking-water at national level, and this assessment provides valuable information for policy-makers and other stakeholders to approach the issue of drinking-water at national and department levels in a more rational, evidence-based way.

5. Recommendations

The following recommendations emerged during the final national workshop. Participants included the technical committee members, the field personnel from MINSA and ENACAL, and leading national professionals.

- The RADWQ survey should be less flexible in its definitions of parameters. The results of the RADWQ survey in Nicaragua will help in the formulation of such a design.
- The time allotted for field work must be meticulously planned and kept as short as possible, given that the goal of the RADWQ pilot studies is to develop a reliable mechanism for rapidly evaluating the water and sanitation situation in a country. The seven weeks needed to complete the survey in Nicaragua were considered to be the maximum limit.
- A computer program is needed for use at local level, which can store information and perform basic analyses. This will help the JMP fulfill one of its responsibilities, to maintain high-quality information that can confidently be used by decision-makers in the water and sanitation sector.
- It is recommended that the findings of this assessment, including clear information about the limitations of the data, be disseminated to the highest ranks of the sector and government. The goals are to facilitate dialogue and analysis of the data, and to develop a workplan to confirm the RADWQ findings and undertake any needed remedial actions.
- The findings should also be disseminated to the peripheral level, not only to health personnel, but also to personnel in related sectors who play an important role in the water and sanitation sector. Examples include employees of municipal authorities and nongovernmental organizations.
- The physicochemical and microbiological findings of the RADWQ survey need to be confirmed by the most appropriate method and as soon as possible, given the parlous state of the water supplies implied by the RADWQ results.
- It is recommended that national institutions identify, or actively promote the development of, the most appropriate techniques for removing arsenic from water supplies. The RADWQ survey results for Nicaragua suggest that arsenic contamination may be a more widespread problem than has been assumed.
- Strengthen or reactivate coordination between organizations, with the goal of raising awareness about better drinking-water for everyone.
- Norms and guidelines for the water and sanitation sector need to be widely disseminated in Nicaragua. Field-work experience revealed that many problems arose because local staff and community members were unaware of such standards, or of the roles played by institutions and community leaders in the RADWQ survey. (See also PIDMA-UNI, 2001, 2002a).
- It is also recommended that the norms and guidelines be strictly observed during feasibility studies of water supplies.

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Annex 1 RADWQ personnel for Nicaragua

Executive Committee (CONAPAS)

Director, INAA.
Director, ENACAL
Director, Department of Hygiene and Environmental Health, MINSA.
Ministry of Natural Resources and Agriculture (MARENA).
Nicaraguan Water and Sanitation Network (RASNIC).

Technical Committee

Philippe Barragne-Bigot, UNICEF.
Maritza Obando, Director, Environmental Health, MINSA.
Lydiester Alvarado, Department of Environmental Management, INAA.
Carolina Ruiz, Environmental Management, ENACAL
Vicente González, Water Quality, ENACAL.
Miguel Angel Balladares, WHO/Pan American Health Organization.
Boanerje Castro, Environmrntal Health, MINSA.
Sergio Gámez, CIEMA-UNI

Supervisors

Lydiester Alvarado Cuadra, INAA.
Boanerge Castro, MINSA.
Tania Larios, UNICEF.
Vicente Gonzales, ENACAL.

Field personnel

Name	Designation	Organization	Department
Ramón Narvaez	Responsible for Environmental Health	MINSA	MAD
Claudia Zapata	Responsible for Environmental Health	MINSA	JIN
Byron García	Responsible for Environmental Health	MINSA	MAT
Bayardo Osorio	Responsible for Environmental Health	MINSA	LEO
Javier Galo	Hygienist	MINSA	CHO
Joaquin Kundano	Responsible for Environmental Health	MINSA	CHO
Abraham Downs Galeano	Responsible for Environmental Health	MINSA	RSJ
Alejandro Castro	Responsible for Environmental Health	MINSA	MAS
Juan Hernandez	Laboratory analyst	MINSA-CNDR	MGA
Danilo Alvarez Mayorga	Epidemiologist	MINSA	MGA
Gerardo Delgado	Supervisor of Programmes	MINSA	MGA
María Esquivel	Responsible for Environmental Health	MINSA	RAAN
Yadira Jimenez	Water Quality Specialist	ENACAL	MGA
Raul Benavides	Head, Regional Laboratory	ENACAL	GRA
José-María Gutierrez	Social Promoter for Hygiene	ENACAL	CHO
José Rivera Maldonado	Head, Regional Laboratory	ENACAL	EST
Moises Toledo	Head, Regional Laboratory	ENACAL	RAAN

Annex 2 RADWQ survey teaching aids (Spanish language version)

Cuestionarios

AGUA POR TUBERÍA: PLANTA/PROCESOS DE TRATAMIENTO

I. Información General:

a. WSS No:…………………………………………........................…………………….…...…..…
b. Comunidad:……………………………………………………………................................
c. Tipos de Procesos de Tratamiento usado:...…….................…...…………...
d. Fecha de la visita:……………………………….……….................….…….…..
e. Muestra de Agua - TTC No:…………………………….……….................……

II. Información de Diagnóstico Específica para Evaluación Riesgo

(Por favor indicar el lugar donde el riesgo fue identificado)

1. Hay quebraduras grietas evidentes en los pre-filtros? S/N
2. Hay escapes fugas en el tanque mezclador? S/N
3. Esta sucio el tanque mezclador? S/N
4. Hay una sobrecarga hidráulica evidente al momento de la toma? S/N
5. Hay algún tanque de sedimentación sucio? S/N
6. Hay algún sistema de distribución del aire y agua con el lecho de arena desnivelado? S/N
7. Hay barro o rajaduras en alguno de los filtros? S/N
8. Hay alguna conexión evidente entre el agua de enjuague y el agua tratada? S/N
9. Hay evidencia de dosificación insuficiente de coagulante (ej. aluminio)? S/N
10. No se alcanzan concentraciones mínimas de cloruro libre residual (minima 0.2mg/l)? S/N

Puntuación Total de los Riesgos ….....…/10

III Resultados y Comentarios:

a. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

b. Se observaron los siguientes puntos importantes de riesgo:
   - (listar nos. 1-10)
   - comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador:

AGUA POR TUBERÍAS: CON RESERVORIOS y: SISTEMAS DE DISTRIBUCION

I. Información General:

a. WSS No:……………………………………………………………………….……………
b. Categoría de Inspección Sanitaria: ……………………………………….....……
c. Comunidad:....…………………………………………………………….……………………
d. Rango de Población: ………………………..........................…………………
e. Fecha de la visita:……………………………………………………….....………..
f. Muestra de Agua – TTC No:…………………………………........……………….

II. Información de Diagnóstico Específica para Evaluación

Importante: Grifos refieren a grifos para inspección o grifos públicos (conectados directamente al sistema de distribución). Un tanque o reservorio de distribución es un reservorio o tanque de abastecimiento de agua en la planta de tratamiento de agua o en su sistema de distribución.

Riesgo

(Por favor indicar el lugar donde el riesgo fue identificado).

1. Hay escape fugas de agua en el grifo o tuberías de donde se obtiene la muestra? S/N
2. Se embalsa empoza el agua alrededor de donde se obtiene la muestra? S/N
3. Hay suciedad alrededor del grifo? S/N
4. Hay una letrina o alcantarillado (desagüe) dentro de 30 m de un grifo? S/N
5. Han habido interrupciones en los últimos 10 días? S/N
6. Esta expuesto/abierto el suministro principal en el área de muestreo? S/N
7. Han reportado los usuarios alguna avería de las tuberías en la última semana? S/N
8. El tanque de suministro está raejado, o tiene escapefugas? S/N
9. Están las válvulas y tapas del tanque dañadas o abiertas? S/N
10. Está la tapa de inspección, o el concreto alrededor de la tapa dañado o corroído? S/N

Puntuación Total de los Riesgos ………../10

III Resultados y Comentarios:

a. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

b. Se observaron los siguientes puntos importantes de riesgo:
   - (listar nos. 1-10)
   - comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador:

<u>DEPOSITO DE AGUA EN EL DOMICILIARDOMICILIO (Agua Domiciliar)</u>

I. Información General:

a. WSS No:……………………………………………………….........……………
b. Comunidad:...………………………………………………….................…….
c. Fecha de la visita:…………………………………………………………………..
d. Muestra de Agua – TTC No:……………………………………..…………..

II. Información de Diagnóstico Específica para Evaluación.

Riesgo

(Por favor indicar el lugar dónde el riesgo fue identificado)

1. Se usa eEl depósito, donde se almacena el agua se usa, también para almacenar otros líquidos? S/N
2. El depósito de agua está al nivel del suelo? S/N
3. La tapa del depósito de agua no está en su lugar o no existe? S/N
4. El depósito de agua está rajado, tiene escape fuga de agua, o está sucio? S/N
5. La área alrededor del depósito de agua está sucia? S/N
6. Animales tienen acceso al área alrededor del depósito? S/N
7. El utensilio o llave para sacar agua del depósito está sucio? S/N
8. Se usa el agua del depósito también para lavarse o bañarse? S/N
9. Ha habido interrupciones en el suministro de agua en los últimos 10 días? S/N
10. Se obtiene el agua del depósito de varias fuentes? S/N

Puntuación Total de los Riesgos **………../10**

III Resultados y Comentarios:

a. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

b. Se observaron los siguientes puntos importantes de riesgo:
- (listar nos. 1-10)
- origen del agua
- comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador

AGUA DOMICILIAR POR TUBERÍAS (agua domiciliar)

I. Información General:

a. WSS No:………………………………………………………………...........……
b. Comunidad:...……………………………………….................………………
c. Fecha de la visita:……………………………………………………………..
d. Muestra de Agua – TTC No:………………………………………….....…….

II. Información de Diagnóstico Específica para Evaluación Riesgo

(Por favor indicar el lugar dónde el riesgo fue identificado)

1. Está el grifo de agua está fuera de la casa (ej. en el patio/jardín)? S/N
2. El agua está almacenada en un depósito dentro de la casa? S/N
3. Hay algunos grifos/llaves dañados o con escape fuga de agua? S/N
4. Algunos de los grifos se comparten con otras casas? S/N
5. La área alrededor del grifo está sucia? S/N
6. Hay fugas en las tuberías de agua de la casa? S/N
7. Animales tienen acceso al área alrededor del grifo?/tubería S/N
8. Han reportado los usuarios alguna avería en las tuberías en la última semana? S/N
9. Ha habido interrupciones en el suministro de agua en los últimos 10 días? S/N
10. Se obtiene el agua de varias fuentes? S/N

Puntuación Total de los Riesgos ………../10

III Resultados y Comentarios:

c. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

d. Se observaron los siguientes puntos importantes de riesgo:
   - (listar nos. 1-10)
   - origen del agua
   - comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador

POZO PERFORADO PROFUNDO CON BOMBA MECANICA MOTORIZADA

I. Información General:

a. WSS No:…………………………………………………………………….........……
b. Comunidad:...……………………………………………..................……………..
c. Fecha de la visita:………………………………………………………………..
d. Muestra de Agua – TTC No:………………………………………………...….

II. Información de Diagnóstico Específica para Evaluación Riesgo

1. Hay alguna letrina o desagüe dentro de 100 m de l sistema dea bombeoa? S/N
2. Hay alguna letrina dentro de 10 m del pozo? S/N
3. Hay alguna fuente de contaminación en un radio de 50 m (ej. corral de animales, cultivo, calles, industrias, etc)? S/N
4. Hay alguna fuente/pozo descubierta en un radio de 100 m? S/N
5. El canal de drenaje está rajado, roto o necesita limpieza? S/N
6. Animales pueden llegar a 50 m del pozo? S/N
7. La base del mecanismo de bombeo es permeable al agua? S/N
8. Se embalsa el agua dentro de 2 m del mecanismo de bombeo? S/N
9. La cubierta o sello de la fuente está sucia? S/N
10. La tapa del pozo está rota? S/N

Puntuación Total de los Riesgos ..../10

III Resultados y Comentarios:

a. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

b. Se observaron los siguientes puntos importantes de riesgo:
- (listar nos. 1-10)
- comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador:

POZO PERFORADO CON BOMBA MANUAL

I. Información General:

a. WSS No.……………………………………………………………..........…......………

b. Comunidad:...………………………………………………….................…………

c. Fecha de la visita:……………………………………………………….....………..

d. Muestra de Agua – TTC No:……………………………….……………....…….

II Información de Diagnóstico Específica para Evaluación Riesgo

1. Hay alguna letrina en un radio de 10 m del pozo? S/N
2. Hay alguna letrina colina arriba del pozo? S/N
3. Hay alguna fuente de contaminación en un radio de 10 m del pozo? (ej. corral de animales, cultivo, calles, industria, etc) S/N
4. El drenaje está dañado lo que permite el embalse de agua en un radio de 2 m del pozo? S/N
5. El canal de drenaje/desfogue está agrietado, roto o necesita limpieza? S/N
6. Animales pueden llegar a 10 m del pozo? S/N
7. La plataforma protectora es menos de 2 m de diámetros? S/N
8. Se almacena el agua recolectada en la plataforma? S/N
9. Está la plataforma o la cubierta de la bomba dañada o agrietada? S/N
10. La bomba de mano está floja en el punto de fijación? (o en caso de bomba a cuerda, es la protección de la bomba ausente?) S/N

Puntuación Total de los Riesgos ………../10

III Resultados y Comentarios:

a. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

b. Se observaron los siguientes puntos importantes de riesgo:
- (listar nos. 1-10)
- comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador:

MANANTIAL PROTEGIDO

I. Información General:

a. WSS No:……………………………………………………..........………..…………

b. Comunidad:...……………………………………………................…………..

c. Fecha de la visita:……………………………………………………………………..

d. Muestra de Agua – TTC No:……………………………………...……………….

II. Información de Diagnóstico Específica para Evaluación Riesgo

1. El manantial está desprotegido? S/N
2. Está dañada la obra de albañilería que protege el manantia? S/N
3. El área de relleno, detrás del muro de contención, está erosionada? S/N
4. El agua derramada inunda el área de acopio de agua? S/N
5. La cerca está ausente o malograda? S/N
6. Animales pueden llegar a 10 m del manantial? S/N
7. Hay alguna letrina colina arriba, o en un radio de 30 m del manantial? S/N
8. Se almacena agua superficial colina arriba del manantial? S/N
9. El canal de desvío sobre el manantial no funciona o está ausente? S/N
10. Hay alguna fuente de contaminación colina arriba del manantial? (ej. desperdicios sólidos) S/N

Puntuación Total de los Riesgos ….........../10

III Resultados y Comentarios:

1. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

2. Se observaron los siguientes puntos importantes de riesgo:
   – (listar nos. 1-10)
   – comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador:

POZO EXCAVADO CON BOMBA MANUAL (Pozo protegido)

I. Información General:

a. WSS No:……………………………………….........……………………..........…………
b. Comunidad:...…………………………………………............................…………
c. Fecha de la visita:……………………………………………………………..........………..
d. Muestra de Agua – TTC No:……………………………...……..........…………….

II. Información de Diagnóstico Específica para Evaluación Riesgo

1. Hay alguna letrina en un radio de 10 m? S/N
2. La letrina más cercana está colina arriba del pozo? S/N
3. Hay alguna fuente de contaminación en un radio de 10 m del pozo? (ej. corral de animales, cultivo, calles, industrias, etc). S/N
4. El drenaje está dañado lo que permite el embalse de agua en un radio de 3 m del pozo? S/N
5. El canal de drenaje está agrietado, roto o necesita limpieza? S/N
6. El cemento alrededor de la parte superior del pozo es menos de 2 m de diámetro? S/N
7. Se embalsa el agua recolectada en la plataforma? S/N
8. El piso de cemento está agrietado? S/N
9. La bomba manual esta floja en el punto de fijación (o en caso de bomba a cuerda, es la protección de la bomba ausente?) S/N
10. La tapa del pozo no existe o está sucia? S/N

Puntuación Total de los Riesgos **...……../10**

III Resultados y Comentarios:

a. Nivel de Riesgo (marque el cuadro apropiado):

9-10 = Muy Alto	6-8 = Alto	3-5 = Mediano	0-2 = Bajo

b. Se observaron los siguientes puntos importantes de riesgo:
- (listar nos. 1-10)
- comentario adicional (continúe al reverso de la página si es necesario)

IV Firma del Evaluador:

CUESTIONARIO PARA SUPERVISORES

Conglomerado #:		Departamento:	
Localidad:		# de muestras supervisadas:	
Área (marcar):	*Pacífico – Norte – Sur – Atlántico*	Categoría Tecnológica:	
Nombre del supervisor:		Fecha de supervisión:	

			EN EL TERRENO:
Si	No	NA	¿ Se sigue un plan de ruta establecido ¿
Si	No	NA	¿ El trabajo esta claramente definido entre el personal ?
Si	No	NA	¿ Se colecta muestras de agua en forma apropiada ¿
Si	No	NA	¿ Las muestras para evaluación microbiológica están en hielo ¿
Si	No	NA	¿ El hielo esta disuelto ?
Si	No	NA	¿ Hay derrame de muestras de agua ?
Si	No	NA	¿ Todos los análisis físicos se hacen apropiadamente ?
Si	No	NA	¿ Se llena siempre el formulario de informe inmediatamente después de hacer el análisis ?
Si	No	NA	¿ Todas las Fichas de Inspección Sanitaria esta completa ?
			EN EL LABORATORIO:
Si	No	NA	¿ La base del laboratorio se usa exclusivamente para la evaluación ?
Si	No	NA	¿ En la base del laboratorio, hay 2 mesas de trabajo ?
Si	No	NA	¿ Están a la vista los instructivos para procesamiento de muestras?
Si	No	NA	¿ El hielo en que se transporta las muestras para evaluación microbiológica esta disuelto al llegar al lab.¿
Si	No	NA	¿ Podría usted afirmar que, en general, el procesamiento de parámetros químicos es correcto ?
Si	No	NA	¿ Se reutilizan los frascos de análisis de parámetros químicos ?
Si	No	NA	¿ Se marca en la base de todas las placas petri, la información requerida ?
Si	No	NA	¿ La información es completa en todas las placas petri ?
Si	No	NA	¿ La temperatura del incubador es 44 grados ?
Si	No	NA	¿ Ha habido interrupción de la energía eléctrica durante el día anterior ?
Si	No	NA	¿ Se anota el resultado del conteo de colonias inmediatamente en la ficha?

Si alguna de las preguntas es respondida con NO, por favor hacer comentarios

OBSERVACIONES, COMENTARIOS: ______________________________

PROCEDIMIENTOS PARA LLENADO DEL CODIGO WSS

El código WSS en el formulario de campo y SanMan identifica detalladamente la procedencia de la muestra obtenida y analizada.

La información contenida el código WSS proviene de:

1. El código inicia con la palabra NIC
2. Sigue 1 dígito que identifica la categoría Tecnológica a la que pertenece la muestra:
    a. 1 = Tubería Pública
    b. 2 = Tubería Comunitaria
    c. 3 = Pozo Perforado
    d. 4 = Pozo Protegido
3. Luego siguen 2 dígitos que identifican el número del conglomerado (1 a 50)
4. El código finaliza con 3 dígitos que identifican el número de muestra

PROCEDIMIENTO PARA ESTERILIZACIÓN DE MATERIAL
- USO MICROBIOLÓGICO -

1. Después de la lectura de Colonias, con Pinzas, desechar las membranas
2. Lavar con agua y jabón todos los recipientes y material
3. Esterilizar placas Petri, pinzas y frascos en la olla de presión:
   - Agregar en la olla aproximadamente 1 lt. de agua
   - Introducir el material a esterilizar
   - Cerrar la tapa
   - Dejar hervir durante 15 minutos
   - Apagar la cocina y Abrir la válvula de escape
   - Esperar 10 minutos
   - Abrir la tapa con cuidado
   - Retirar el material cuidadosamente

El material desechado debe ser cuidadosamente colocado en un envase para su incineración posterior

PROCEDIMIENTOS PARA ANALISIS QUÍMICOS

HIERRO

1. Seleccione la longitud de Onda en el fotómetro a 570 nm
2. Medir 10 ml de la muestra de agua en el tubo de ensayo
3. Agregar 1 tableta de **" Iron HR"** triturarla y disolverla bien
   Mézclese hasta que se disuelva
4. Dejar en reposo por 1 minuto
5. Leer resultados en el fotómetro : colocar primero el frasco "blanco" en el orificio izquierdo, luego cuando la lectura llegue a 100, hacer rápidamente el cambio de frascos y leer el resultado
6. Leer el resultado en la tabla respectiva
7. Anotar el resultado de la tabla en el formulario

FLUORURO

1. Seleccione la longitud de Onda en el fotómetro a 570 nm
2. Medir 10 ml de la muestra de agua en el tubo de ensayo
3. Agregar 1 tableta **" Fluoride #1"** triturarla y disolverla bien
4. Adicionar 1 tableta **" Fluoride #2"** triturarla y disolverla bien
5. Dejar en reposo por 5 minutos
6. Leer resultados en el fotómetro : colocar primero el frasco "blanco" en el orificio izquierdo, luego cuando la lectura llegue a 100, hacer rápidamente el cambio de frascos y leer el resultado
7. Leer el resultado en la tabla respectiva
8. Anotar el resultado de la tabla en el formulario

COBRE

1. Seleccione la longitud de Onda en el fotómetro a 520 nm
2. Llenar 10 ml de la muestra de agua en el tubo de ensayo
3. Agregar 1 tableta **" Coppercol #1"** triturar y disolverla bien
4. Agregar 1 tableta **" Coppercol #2"** triturar y disolverla bien
5. Dejar en reposo por 1 minuto
6. Leer resultados en el fotómetro : colocar primero el frasco "blanco" en el orificio izquierdo, luego cuando la lectura llegue a 100, hacer rápidamente el cambio de frascos y leer el resultado
7. Leer el resultado en la tabla respectiva
8. Anotar el resultado de la tabla en el formulario

NITRATOS

1. Seleccione la longitud de Onda en el fotómetro a 570 nm
2. Medir 20 ml de la muestra de agua en en el tubo de ensayo.
3. **ADICIONAR** 1 medida "cucharadita" de **"Nitratest Powder"**
4. Agregar 1 tableta de **"Nitratest Tablet"**, tapar y agitar bien (no romper la tableta).
5. Espere 1 minuto a que sedimente el contenido del tubo.
6. Invierta el tubo 3 o 4 veces suavemente
7. Transfiera 10 ml de la solución anterior a un tubo de ensayo de 10 ml.
8. Agregar una tableta de **" Nitricol "**, triturarla y mezclar hasta que se disuelva
9. Dejar en reposo por 10 minutos.
10. Leer resultados en el fotómetro : colocar primero el frasco "blanco" en el orificio izquierdo, luego cuando la lectura llegue a 100, hacer rápidamente el cambio de frascos y leer el resultado

11. Leer el resultado en la tabla respectiva
12. Anotar el resultado de la tabla en el formulario

CLORO TOTAL Y RESIDUAL

1. Medir 10 ml de la muestra de agua en el tubo de ensayo
2. Agregar 1 tableta **" # 1"** triturarla y disolverla bien
   Mézclese hasta que se disuelva
3. Leer resultados = Cloro Residual
4. Agregar 1 tableta **" # 3"** triturarla y disolverla bien
   Mézclese hasta que se disuelva
5. Leer resultados = Cloro Total
6. Anotar los resultados en el formulario

ARSENICO

1. Llene la trampa de arsénico de triple filtro (Bung).
2. Ponga el filtro para eliminación de sulfuro de hidrógeno en la parte inferior de la trampa
3. Llene la cuñita negra con su respectivo filtro. (frasco con etiqueta negra). Prepare una cuñita negra extra para calibrar el equipo
4. Llene la cuñita roja con su respectivo filtro. (frasco con etiqueta roja)
5. Inserte las cuñitas en la trampa triple
6. Mida 50 ml de muestra en frasco erlenmeyer de 100 ml
7. Adicionar el paquetito **"A1, Acido Sulfámico"**. Agitar hasta disolución
8. Encienda el *ARSENATOR* oprimiendo cualquiera de las dos teclas, espere que aparezca la palabra *INSERTE SLIDE*, introduzca la cuñita negra para calibrar el equipo
9. Adicionar tableta **"A2, Borhidrato de Sodio"** y tapar inmediatamente el erlenmeyer con la trampa triple
10. Retirar la cuñita del *ARSENATOR* y el cronómetro se activará automáticamente
11. Después de 20 minutos retire la trampa triple y retire la cuñita negra
12. Introduzca la cuñita negra en el *ARSENATOR* y espere el resultado

Annex 3 Work plan for the RADWQ survey in Nicaragua

Timeline of activities

Evaluación Rápida de la Calidad del Agua de Bebida (ERCAB - RADWQ)
WHO/UNICEF - Nicaragua
Plan de trabajo de campo 25 de octubre al 10 diciembre 2004

Base		Oct	Nov					Dic
PACIFICO	Municipios	25-29	01-05	08-12	15-19	22-26	29-03	06-10
Granada	Diria-Diriomo	▬						
Masaya	Masaya	▬						
Managua	Managua	▬						
Rivas	Rivas	▬						
NORTE								
Ocotal	Jicaro		▬					
	Quilali-Macuelizo-Sta. Maria			▬				
Somoto	Sn. Lucas-Las Sábanas				▬			
	Palacagüina					▬		
Esteli	Condega-Palacagüina		▬					
	Sn. J. de Limay-Pblo. Nuevo			▬	▬			
	Esteli					▬		
Esteli	Esteli		▬	▬				
Matagalpa	Ciudad Dario				▬			
	Sébaco					▬		
Jinotega	Jinotega		▬					
Matagalpa	Maniguas-Muy Muy-Paiwas			▬	▬			
	Sn. Ramón-La Dalia					▬		
SUR								
Matagalpa	Matagalpa						▬	
Boaco	Sta. Lucia-Teustepe-Sn. Lorenzo-Sn. J. de los Remates							▬
Boaco	Sto. Tomás – Camoapa						▬	
	Boaco							▬
Nva. Guinea	Nueva Guinea-El Almendro						▬	
	Morrito-San Carlos							▬
ATLANTICO								
Siuna	Siuna						▬	
Waspán – Pto.	Waspán-Pto. Cabezas							▬

Field personnel, RADWQ Survey, Nicaragua, 25 October–10 December, 2004

Equipo	Conglom#	Area	Tecnologia	Tamaño conglo.	Base del lab	Municipios involucrados	Dep.	Lab1	Lab2	Field1	Field2
1	1	Pacifico	T. Pública	65	Granada	Diria-Diriomo	GRA	gra_e2		mad1	rsj1
2	2	Pacifico	T. Pública	65	Masaya	Masaya	MAS	leo1		cho2	mas1
3	3	Pacifico	T. Pública	65	Managua	Managua	MGA	mga_e1	mga1	mga2	mga3
4	4	Pacifico	T. Pública	65	Rivas	Rivas	RIV	cho1		mat1	jin1
1	5	Norte	P. Protegido	50	Ocotal	Jícaro	NSG	mga1		mad1	rsj1
1	6	Norte	P. Protegido	50	Ocotal	Quilali-Macuelizo-Sta. María	NSG	mga1		mad1	rsj1
1	7	Norte	P. Perforado	50	Somoto	Sn. Lucas-Yalagüina-Telpaneca-Las Sábanas	MAD	mga1		mad1	rsj1
1	8	Norte	P. Protegido	50	Somoto	S. Lucas-Somoto-Las Sábanas-Sn. J. de Cusmapa	MAD	mga1		mad1	rsj1
1	9	Norte	T. Comunitaria	50	Somoto	Palacagüina-Telpaneca-Yalagüina-Condega-Pblo. Nvo.	MAD - EST	mga1		mad1	rsj1
2	10	Norte	P. Perforado	50	Esteli	Condega-Palacagüina	MAD - EST	est_e4		cho2	mas1
2	11	Norte	P. Perforado	50	Esteli	Sn. J. de Limay-Pblo. Nuevo	EST	est_e4		cho2	mas1
2	12	Norte	P. Protegido	50	Esteli	Sn. J. de Limay-Pblo. Nuevo-San Nicolás	EST	est_e4		cho2	mas1
2	13	Norte	T. Comunitaria	50	Esteli	Estelí-San J. de Limay-San Nicolás	EST	est_e4		cho2	mas1
2	14	Norte	T. Pública	30	Esteli	Estelí	EST	est_e4		cho2	mas1
3	15	Norte	P. Perforado	50	Esteli	Estelí	EST	cho1		mga2	mga3
3	16	Norte	P. Protegido	50	Esteli	Estelí-La Trinidad	EST	cho1		mga2	mga3
3	17	Norte	P. Perforado	50	Mat [Séb/C Dario]	Ciudad Darío	MAT	cho1		mga2	mga3
3	18	Norte	P. Perforado	50	Mat [Séb/C Dario]	Sébaco-Terrabona	MAT	cho1		mga2	mga3
3	19	Norte	P. Protegido	50	Mat [Séb/C Dario]	Ciudad Darío-San Isidro-Sébaco-Terrabona	MAT	cho1		mga2	mga3
4	20	Norte	T. Comunitaria	50	Jinotega	Jinotega	JIN	leo1		mat1	jin1
4	21	Norte	T. Comunitaria	50	Matagalpa	Maniguas-Muy Muy-Paiwas-Río Blanco	MAT	leo1		mat1	jin1
4	22	Norte	P. Perforado	50	Matagalpa	Sn. Ramón-La Dalia	MAT	leo1		mat1	jin1
4	23	Norte	P. Protegido	50	Matagalpa	Matagalpa-Matiguas-San Ramón-El Tuna-Río Blanco-Paiwas	MAT	leo1		mat1	jin1
4	24	Norte	T. Comunitaria	50	Matagalpa	Matagalpa	MAT	leo1		mat1	jin1
4	25	Sur	P. Protegido	10	Boaco {*Teust*}	Sn. Lorenzo	BOA	leo1		mat1	jin1
4	26	Sur	P. Perforado	10	Boaco	Boaco-Santa Lucía	BOA	leo1		mat1	jin1
4	27	Sur	T. Pública	10	Boaco {*Teust*}	Teustepe	BOA	leo1		mat1	jin1
4	28	Sur	P. Protegido	10	Boaco {*Teust*}	Teustepe	BOA	leo1		mat1	jin1
4	29	Sur	P. Perforado	10	Boaco	San José de los Remates	BOA	leo1		mat1	jin1
2	30	Sur	P. Perforado	10	Boaco	Camoapa	BOA	mas1	cho2	cho_e3	mga2
2	31	Sur	P. Protegido	10	Boaco	Camoapa	BOA	mas1	cho2	cho_e3	mga2
2	32	Sur	T. Pública	10	Boaco	Sto. Tomás	CHO	mas1	cho2	cho_e3	mga2
2	33	Sur	P. Perforado	10	Boaco	Boaco-Santa Lucía	BOA	mas1	cho2	cho_e3	mga2
2	34	Sur	P. Perforado	10	Boaco	Boaco-Santa Lucía	BOA	mas1	cho2	cho_e3	mga2
2	35	Sur	P. Protegido	10	Boaco	Boaco	BOA	mas1	cho2	cho_e3	mga2
3	36	Sur	T. Comunitaria	10	Nva. Guinea	Nueva Guinea	CHO	cho1		mad1	rsj1
3	37	Sur	T. Comunitaria	10	Nva. Guinea	Nueva Guinea	CHO	cho1		mad1	rsj1
3	38	Sur	T. Pública	10	Nva. Guinea	Nueva Guinea	CHO	cho1		mad1	rsj1
3	39	Sur	P. Perforado	10	Nva. Guinea	El Almendro	RSJ	cho1		mad1	rsj1
3	40	Sur	P. Protegido	10	Nva. Guinea	Morrito	RSJ	cho1		mad1	rsj1
3	41	Sur	P. Protegido	10	Nva. Guinea	San Carlos	RSJ	cho1		mad1	rsj1

3	42	Sur	P. Protegido	10	Nva. Guinea	San Carlos	RSJ	cho1		mad1	rsj1
4	43	Atlantic	T. Pública	10	Pto. Cabezas	Pto. Cabezas	RAAN	raan_e5	mga1	raan_1	mga3
4	44	Atlantic	P. Protegido	10	Pto. Cabezas	Pto. Cabezas	RAAN	raan_e5	mga1	raan_1	mga3
4	45	Atlantic	P. Protegido	10	Siuna	Siuna	RAAN	raan_e5	mga1	raan_1	mga3
4	46	Atlantic	P. Protegido	10	Siuna	Siuna	RAAN	raan_e5	mga1	raan_1	mga3
4	47	Atlantic	P. Protegido	10	Siuna	Siuna	RAAN	raan_e5	mga1	raan_1	mga3
4	48	Atlantic	P. Protegido	10	Waspán	Waspán	RAAN	raan_e5	mga1	raan_1	mga3
4	49	Atlantico	P. Protegido	10	Waspán	Waspán	RAAN	raan_e5	mga1	raan_1	mga3
4	50	Atlantico	P. Protegido	10	Waspán	Waspán	RAAN	raan_e5	mga1	raan_1	mga3

Annex 4 Sanitary risk factors used in the RADWQ survey of Nicaraguan water supplies

Table A4.1 Percentage of public piped water supplies positive for sanitary risk factors, by broad area

	Risk factor	Pacific	Central North	Central South	Atlantic
1.	Do any taps or pipes leak at the sample site?	11.3	8.6	0.0	40
2.	Does water collect around the sample site?	23.5	15.5	10.3	10
3.	Is the area around the tap unsanitary?	42.9	41.4	48.3	0
4.	Is there a sewer or latrine within 30 m of any tap?	42.0	12.1	48.3	20
5.	Has there been discontinuity in the last 10 days?	74.4	22.4	65.5	0
6.	Is the supply main exposed in the sampling area?	44.5	6.9	31.0	0
7.	Have users reported any pipe breaks within the last week?	12.2	5.2	10.3	0
8.	Is the supply tank cracked or leaking?	7.1	15.5	10.3	0
9.	Are the vents and covers on the tank damaged or open?	0.8	12.1	10.3	50
10.	Is the inspection cover or the concrete around the cover damaged or corroded?	0.4	3.5	10.3	0

Table A4.2 Percentage of community supplies positive for risk factors, by broad area

	Risk factor	Pacific	Central North	Central South	Atlantic
1.	Do any taps or pipes leak at the sample site?		58.3	34.3	0.0
2.	Does water collect around the sample site?		76.8	62.9	0.0
3.	Is the area around the tap unsanitary?		76.3	85.7	100.0
4.	Is there a sewer or latrine within 30 m of any tap?		81.4	85.7	0.0
5.	Has there been discontinuity in the last 10 days?		25.3	37.1	0.0
6.	Is the supply main exposed in the sampling area?		73.7	67.1	100.0
7.	Have users reported any pipe breaks within the last week?		11.9	10.0	0.0
8.	Is the supply tank cracked or leaking?		18.0	2.9	0.0
9.	Are the vents and covers on the tank damaged or open?		8.3	2.9	0.0
10.	Is the inspection cover or the concrete around the cover damaged or corroded?		4.6	4.3	0.0

Table A4.3 **Percentage of boreholes positive for sanitary risk factors, by broad area**

	Risk factor	Pacific	Central North	Central South	Atlantic
1.	Is there a latrine within 10 m of the borehole?		21.6	41.7	
2.	Is there a latrine uphill of the borehole?		23.2	40.3	
3.	Are there any other sources of pollution within 10 m of borehole (e.g. animal breeding, cultivation, roads, industry etc.)?		65.4	72.2	
4.	Is the drainage faulty, allowing ponding within 2 m of the borehole?		21.1	33.3	
5.	Is the drainage channel cracked, broken or in need of cleaning?		35.1	40.3	
6.	Can animals come within 10 m of the borehole?		66.2	40.3	
7.	Is the apron less than 2 m in diameter?		33.8	34.7	
8.	Does spilt water collect in the apron area?		27.8	26.4	
9.	Is the apron or pump cover cracked or damaged?		12.7	23.6	
10.	Is the hand pump loose at the point of attachment, or (for a rope-washer pump) is the pump cover missing)?		8.7	16.7	

Table A4.4 **Percentage of protected wells positive for sanitary risk factors, by broad area**

	Risk factor	Pacific	Central North	Central South	Atlantic
1.	Is there a latrine within 10 m of the well?		30.1	54.9	1.5
2.	Is the nearest latrine uphill of the well?		32.7	32.4	1.5
3.	Are there any other sources of pollution within 10 m of borehole (e.g. animal breeding, cultivation, roads, industry etc.)?		85.6	77.5	13.0
4.	Is the drainage faulty, allowing ponding within 3 m of the well?		33.3	31.0	17.4
5.	Is the drainage channel cracked, broken or in need of cleaning?		46.4	50.7	17.4
6.	Is the cement apron less than 2 m in diameter around the top of the well?		36.6	23.9	52.2
7.	Does spilt water collect in the apron area?		37.6	29.6	44.9
8.	Are there cracks in the cement floor?		51.6	47.9	11.6
9.	Is the hand pump loose at the point of attachment, or (for a rope-washer pump) is the pump cover missing)?		11.8	9.9	7.3
10.	Is the well-cover absent or unsanitary?		24.8	35.2	11.6

Table A4.5 **Percentage of public and community water supplies positive for sanitary risk factors, according to the presence or absence of thermotolerant coliforms**

Risk factor		Public		Community	
		Absent	Present	Absent	Present
1.	Do any taps or pipes leak at the sample site?	11.0	8.8	57.3	47.8
2.	Does water collect around the sample site?	18.9	35.3	74.8	71.4
3.	Is the area around the tap unsanitary?	40.2	55.9	75.7	80.8
4.	Is there a sewer or latrine within 30 m of any tap	34.2	58.8	76.7	85.7
5.	Has there been a supply discontinuity in the last 10 days?	60.8	76.5	25.2	29.8
6.	Is the supply main exposed in the sampling area?	36.2	29.4	67.9	74.5
7.	Have users reported any pipe breaks within the last week	10.6	8.8	7.8	13.0
8.	Is the supply tank cracked or leaking?	9.0	5.9	10.7	16.2
9.	Are the vents and covers on the tank damaged or open?	5.0	5.9	3.9	8.7
10.	Is the inspection cover or concrete around the cover damaged or corroded?	1.7	2.9	2.9	4.2

Table A4.6 **Percentage of boreholes positive for sanitary risk factors, according to the presence or absence of thermotolerant coliforms**

Risk factor		Absent	Present
1.	Is there a latrine within 10 m of the borehole?	32.7	17.5
2.	Is there a latrine uphill of the borehole?	34.7	18.0
3.	Are there any other sources of pollution within 10 m of the borehole (e.g. animal breeding, cultivation, roads, industry etc.)?	63.8	68.8
4.	Is the drainage faulty, allowing ponding within 2 m of the borehole?	20.6	25.2
5.	Is the drainage channel cracked, broken or need cleaning?	34.2	38.5
6.	Can animals come within 10 m of the borehole?	59.3	65.0
7.	Is the apron less than 2 m in diameter?	43.7	26.5
8.	Does spilt water collect in the apron area?	25.1	30.3
9.	Is the apron or pump cover cracked or damaged?	12.1	16.2
10.	Is the hand pump loose at the point of attachment, or (for a rope-washer pump) is the pump cover missing?	9.0	10.7

Table A4.7 **Percentage of protected wells positive for sanitary risk factors, according to the presence or absence of thermotolerant coliforms**

	Risk factor	Absent	Present
1.	Is there a latrine within 10 m of the well?	28.6	30.3
2.	Is the nearest latrine uphill of the well?	25.0	28.9
3.	Are there any other sources of pollution within 10 m of the borehole (e.g. animal breeding, cultivation, roads, industry etc.)?	60.7	76.4
4.	Is the drainage faulty, allowing ponding within 3 m of the well?	22.6	32.0
5.	Is the drainage channel cracked, broken or in need of cleaning?	26.2	46.9
6.	Is the cement less than 2 m in diameter around the top of the well?	50.0	34.0
7.	Does spilt water collect in the apron area?	35.7	37.9
8.	Are there cracks in the cement floor?	29.8	48.6
9.	Is the hand pump loose at the point of attachment or (for a rope-washer pump) is the pump cover missing?	10.7	11.0
10.	Is the well cover absent or unsanitary?	17.9	26.1

World Health Organization
Avenue Appia 20
1211 Geneva 27, Switzerland

United Nations Children's Fund
3 UN Plaza
New York, NY 10017, USA

9 789241 500586