

## New Water and Watershed Paradigms in the Independencia Basin since 1998

Dr. Marcos Adrian Ortega-Guerrero, from the Centre of Geosciences, UNAM, Campus Juriquilla, Qto. With the launch of the Water Awareness Campaign, Agua Vida SMA, and the celebration of the equinox in the Charco del Ingenio, March 23rd 2013.

Introduction by Cesar Arias;

In the name of the Botanical Garden of Charco del Ingenio, we offer you the most heartfelt welcome to this very special day for us and for the whole of San Miguel, firstly the celebration of the Spring Equinox, from this festival of the re-birth of the Earth, this festival of the sun, which is very important here in for us in the Botanical Garden and which this year fortunately coincides with the celebration of World Water Day declared by the UN and that is celebrated all around the world and here in San Miguel de Allende, as we all know, has a very special character, of great importance for the water situation that we live in San Miguel de Allende.

So, one way of celebrating both occasions, two important elements for us, and at the same time I would like to welcome to star this day the person, I think the most suitable person to be with us on this occasion, Dr. Marcos Adrián Ortega, researcher from the Geosciences Centre of the National University of Mexico, the UNAM, Juriquilla campus, he, I mean to say, that since many years ago, he has been studying, investigating the situation of the aquifer, which gives us life here in San Miguel de Allende and he is not only a top quality researcher, of the first class who we admire enormously, but who is also a very brave man for having confronted, and having not bended to the interests of politicians or economists and has always demonstrated the truth with respect to the aquifer situation, what's more he is a great friend of ours and it gives us great pleasure to have him here again in the Charco del Ingenio.

Before I hand over to Dr. Marcos Adrián, I would also like to welcome the members of the Cieneguita community here in san Miguel, who are en the middle of a great battle for the defence of their spring, that is currently threatened by private interests that could kill the spring, and so, well they are here with great interest to listen to Dr. Ortega and we are all here together, welcome and we hope to see you more often at the Charco del Ingenio.

Dr Adrián Ortega:

Thankyou verymuch Cesar, it is a pleasure to be here with all of you in the Charco del Ingenio. It has been a while since we last exchanged ideas, scenarios related with the water issues in the region. So I am very happy to be here with you, as soon as I arrived you have been asking me lots of questions, therefore we are already in the heat of the debate, so we are going to try to go through

the material, something new, something a bit older, 10 years or so, but in geological terms that is practically recent and the topic will be subjected to new paradigms, we named this lecture after the new paradigms because they deal with the changes that we have to establish to be able to arrive at the solutions... eh, the lecture then deals with paradigms related to water as much as to the watershed, such as in the Independencia aquifer, which is officially recognized as the 'cuenca alta del rio la Laja' we call it 'Cuenca y Acuífero de la Independencia' for many reasons which you will get to know by the end of the talk, and well, many of you already know.

Before we begin I would like to publicly recognize many of the people and institutions that have participated over the last 10 years or more in helping these studies in the Independencia watershed, since the CODEREG's that were the 'Consejos Regionales para el Desarrollo del Estado de Guanajuato' [Regional Development Committees] of the state of Guanajuato, as much in the North as in the North-East in the periods mentioned there, to numerous colleagues and students of the Universidad Nacional, other international and national universities and numerous organizations and people who spend most of their time here in the watershed of the Independencia. If you ask me what is the current state of the aquifer after 10 or 12 years since we completed the first studies we can say that the extraction continues. 10 or 12 years ago there were around 2500 wells, now there are closer to 3000 wells, which have obviously increased the extraction from this aquifer. Actually, it is estimated that the extraction is in the order of thousands of millions of cubic metres, this is an important fact because in the past, about 50 years ago or more, when the aquifer was still being recharged, we will see later on why this is no longer the case, this process has already been interrupted, the natural recharge was in the order of between 200 and 300 millions of cubic metres per year, and the current extraction is in the order of thousands of millions, you can compare this to a bank account where we are progressively extracting more than our reserves.

The descent of the phreatic zones continue, still in the order of 10 metres per year, that is to say that the phreatic zone is descending at such a velocity, each time deeper, we are going to see these images with the position of this level in the watershed. Another of the problems that we observe is that the quality of the water continues to deteriorate, there is a constant increase in the concentrations of flourine, fluoride, arsenic and sodium, among other elements which we will not go into detail about in this talk. And obviously, the area impacted by this problem of quality is also increasing in the number of square kilometres and hectares in the interior of the watershed, this would be the summary, that excessive water extraction is maintained, the aquifer continues to be mined and the chemical elements keep increasing in the water.

This is the location of the aquifer, in fact here it is also here in this image of the Lerma-Chapala watershed, the Lerma-Chapala watershed is this one here, highlighted in green, this is the Chapala lake, the state of Guanajuato is in red and the studies in which the university has participated is in the Independencia aquifer, the 'cuenca alta del rio la Laja' (the upper watershed of the river la Laja) and also the part of the aquifer of the Bajio in the southwest, we are going to concentrate the lecture on the independence aquifer, here you have a scale so that you have the dimensions of the watershed, which are in the order of 100 km by 70 km, we are talking about 7000 km squared which is the area of this watershed.

The objectives of the lecture are to demonstrate the most recent advances in our knowledge about the aquifer and its evolution. And to present these new paradigms that we have to arrive at the solutions. Adequate solutions have not been implemented before because we have not changed our way of thinking, we have not adapted to new paradigms. The greatest part of the material that I will show you today was published in this journal in 2009, it is the 'Revista Mexicana de Ciencias Geológicas', 'Occurrence, distribution, hydrochemistry and origin of arsenic, fluoride and other trace elements dissolved in groundwater at basin scale in central Mexico'. You can find this on the internet, it is available on the webpage of the Revista Mexicana de Ciencias Geológicas (<http://tinyurl.com/n5dmngg>). I will show you other references that may be of use at the end. Ok, here is the location of the watershed in the state of Guanajuato and the municipalities of San José Iturbide, Doctor Mora, San Luis de la Paz, San Diego de la Unión, San Felipe, Dolores Hidalgo y San Miguel de Allende form a part of this great watershed. These would be the areas involved in the aquifer, where Dolores Hidalgo practically comprises the greatest percentage, or almost the entirety of the interior of the basin, here is San Miguel de Allende and here is the Presa Allende, remember this shape because we are going to show you a few images relating to San Miguel.

This map shows the ground elevation, it is a computer-generated map, we have a Geo-informatic system (GIS) that has been generated during the studies that allow us to have all the information integrated into this system, we can go from this scale down to much smaller scale with the location of wells and all the characteristics of them, of those that we studied, something important that you see is that the watershed is principally delineated by the mountains that are presented by the yellow and red colours, they are the zones with the greatest elevation and the lowest parts are those that are shown in light green and blue, an important thing to highlight is that this is a watershed with only one exit here in what is now the Presa in San Miguel de Allende. All of the runoff from the watershed leaves through the river La Laja and other lesser rivers and discharge directly into the southern part of the Bajío, this is important because, believe it or not, officially the watershed is divided into two parts, this portion here to the right is managed as the closed watershed of the Laguna Seca, it is not, you can take note that this simple image is not [a closed watershed], and we will also show isotopic data of the water in the sub-soil that demonstrate that this has not been a closed watershed in the recent past nor in geological time, this is very important because here a different board takes different decision to those taken in the other section. That which divides the input of ideas and approaches to solutions of problems.

The watershed is complicated, from a geological point of view, here you can see in different colours, different types of rocks, in green, that are these here, practically on the right of the fault in San Miguel de Allende, this is a very important fault that displaces the crust more than 30 km deep and extends all the way to Taxco in the state of Guerrero, it is a fault that has a very important displacement of the crust, in green you can see the rocks that are from the Cretaceous period, they are marine rocks, before, 60, 150 million years ago there was a deep ocean here, tectonic plate movement has left these witnesses of the dinosaur epoch, however there were no dinosaurs in this region, that's why we don't find them in these rocks, we find marine fossils.

And the rest of the rocks, shown in light pink, dark pink, the orange ones correspond with volcanic rocks, they are volcanic rocks composed of rhyolite, that are going to play a very important role as much in the flow as in the chemistry of the groundwater and not only of the water, also in other environmental problems.

To understand or introduce some fundamental concepts which we are going to discuss, there exists a very important concept in the watershed, a concept dating back to 1960 when a Canadian researcher, John, a learned man in the 60's, started to revise thousands of data points of deep wells in Alberta, Canada and then over many decades summarized his work into this diagram that you can see here in this section, like a slice of cake that we cut along the length of the watershed and we can see here the different types of flow that are generated in terms of ground water.

Taking into account that this part that you see here represents the mountainous western zone of the Independencia watershed, and this is the eastern part, this part here will represent the lower part where the river la Laja drains, which is derived from various flow systems that is dominated by the shallowest local flows that you see here, they are flows that take between weeks and years to drain since their arrival to the mountain, following this trajectory the flow is descending vertically, and prior it tends to exit, these zones respond to areas of springs, cold springs with low dissolved salts. Other systems exist which are much deeper that also receive water in the mountainous regions, the recharge zones and travel to great depths, here we could be talking about the order of one or two thousand metres deep. In the same way that the water, after travelling thousands of metres vertically down, a horizontal flow is incorporated to later exit in this boundary that corresponds to superficial water flow, the river will be in this zone, so it really represents a barrier to the flow and the water tends to exit, the important fact about this flow is that it also repeats on this other side and discharges, here is its residence time, the time it takes the water since its arrival until its exit and is in the order of thousands of years, there is, obviously you can differentiate between the local flow and the deep flow, there is an intermediate flow whose journey takes hundreds of years, this is very important because it brings us to the concept that water has an age, and this age is fundamental in the renewal of water and also the use that we give to the water, obviously the water is here, shallower, with short journeys, I told you that it is cold with few dissolved salts while the deep flows have high concentrations of salts and it is normally thermal water for the depths at which they circulate, for this region you find zones like the north of San Miguel, hot water springs and cold water springs, for example, the Cieneguita spring receives a large local recharge, it would be within an intermediate system because it has a temperature of 32, 34 degrees, so this is already a spring with these characteristics, there are others with much warmer water, from 40, 50 degrees that correspond to a discharge of a more ancient water flow in the order of thousands of years and in addition circulate around much deeper rocks, once you have understood this, pardon me, I lost my train of thought there, when we talk about the recharge of aquifers, it is not a simple term, it is a particularly complicated term that depends on the zones

which cause and induce the recharge, if in this zone here, if we could inject water into this zone it would take thousands of years to reappear, do you all agree? While if we take advantage of the local flows the water will enter in a direct way. Just that in this watershed we are going to demonstrate later but I will take a moment to mention that we already use the young water, the water that is days, weeks or a few years old, we already use that, now we are using much deeper water, much warmer and older, we are going to see what kind of ages we are talking about.

Within the aspects which are worth pointing out, are these three figures that show the time in years, we are taking here of the 40's, until 2010, 2020 over there and they show three different characteristics in the use of the water in the watershed, one is the area of irrigation with time, this varies from 10 thousand up to 50 thousand hectares over time, that graphic over there is the number of wells over the same time intervals, two thousand and three thousand in would be around there, this is the volume of extraction that goes from 0 to 500, the graph is cut off, it should appear as three thousand over there, sorry, one thousand that mentioned billions of cubic metres per year. Therefore you can see that the number of hectares of irrigation has increased exponentially and equally the number of wells reaches close to 3 thousand and with extractions in the order of thousands of millions of metres cubed, this is the reality of what has happened over the last 10 or 12 years, the irrigation zones have increased, the number of wells and the volumes of extraction despite the existence of other zones of the aquifer which given its limited density, the wells are already dry, mainly in the northeast of the basin. This is one, I don't very much like this figure because the lines are too close together but it tries to show the depth at which one finds the phreatic zone, it is the level of saturation below which all the empty spaces are full of water in a porous medium. Under natural conditions this watershed was a full container, imagine a bucket full of sand, gravel, where we add water over thousands of years and we reach a level practically at the surface, this was the situation 60 or 70 years ago. 10 years ago, in this part of the watershed, close to San Luis de la Paz, San Diego de la Union, San Miguel is here, the saturation levels, the phreatic levels were 150 metres deep, that used to be at the surface, 10 years ago they were 150 metres here, 120 in this zone around Dolores Hidalgo, 120 metres also here, the effect of the Presa shows us of 10 metres for the influence of the Presa and in this region up to 50 metres, but we are going to see it in terms of flow, well, sorry, actually the levels in this part of the watershed are at 200 metres, so you can derive a very simple linear function that the descent is in the order of 2 to 10 metres per year, this zone of San Miguel has peculiar characteristics that we shall see after, this represent the energy that the water has, these lines that you see, these here that have a number represent the lines of equal energy that the water has with respect to the sea, which is to say that here we have an equipotential of two thousand metres and progressively descend towards the interior of the watershed, to 1850 metres, 1820 here, this indicates that the flow of water moves to the zones of highest charge, the highest potential to the zones of least potential, equally the temperature, so it generates this movement of water represented by the arrows, you can observe that it forms big depression cones, this is very important because we are generating wide zones of the aquifer where we no longer have water filling these pores, but they are found at great depths and, it is important because we are going to discover that there are certain chemical characteristics in these portions. Here it is shown that much of the water in the Presa is returning to the aquifer, it is good that part

of this water returns to the aquifer even though it has problems of quality, above all for residual water that contaminate the wells with organic matter.

Ok, this is to show you that all these points, of the 2500 wells that existed 10 or 20, 10 or 12 years ago, we took samples of close to 300 of these wells that are represented here, these samples were analysed for 75 chemical elements, it is the first time that a study involves so many elements in its analysis and we are going to take a look at the importance of them. We also took samples to age the water; we applied techniques of enriched tritium. You all know that tritium is associated with atomic tests, in this case principally tests by the United States, and that the levels of tritium in the atmosphere are elevated and we can use these levels as a tracer to correlate to the age of the water, if we find tritium in groundwater, we know that the water we know that the age of the water is younger than 60 or 70 years, it is young water for us, and if we do not find tritium, it means that the water is much older than 60 or 70 years. Moving on to some of the results, we find tritium outside of a couple of wells here close to Zamorano which is a very tall volcano and in the rest of the aquifer we do not find evidence of tritium, which tells us that the water was older than 60 or 70 years. To find out the age we use carbon-13, carbon-14, in this point here, that shows different zones of the aquifer and we find that the age of the water varies between 10 thousand years in the eastern zone close to San Miguel and 35 million years old towards San Diego de la Unión.

That is the age of the water that we are currently using from the aquifer, it is ancient water, we already finished the young water, we continue to use it. More recent analysis of the carbon-13, carbon-14, in one part here, close to San Luis de la Paz, also gave us close data, without doing corrections for 50 thousand year, do you remember the deep flows that we saw in the first diagram? To use the young water we are inducing the migration of these regional flows towards the superior aquifer.

This is one of the problems that we also find in the aquifer, this is an image of 10, 15, 10 years ago sorry, there are high concentrations of fluorine in the water, and these high concentrations of fluorine bring with them numerous illnesses, among them dental fluorosis, skeletal fluorosis, but the most severe damage is in the neurotransmitters of children, in China various publications have just been released that show that children that drink water with fluorine reduce their intellectual coefficient up to 20%, in many of these communities that are here which are hundreds of communities in this section, we are also going to see here in the zone of San Miguel, according to previous studies, the children have learning difficulties, but also another series of illnesses, including muscular pain, permanent headaches, already in advanced cases, in women it causes problems of miscarriage, child mortality and in men, only now I think that they are paying more attention to this problem because it also causes erectil disfunction, so now that the male civil servants are paying attention, and well, there are already proposals from the women in the watershed that say that to procreate they must leave the watershed or bring new men to the watershed, from other basins..."

There is also a great deal of arsenic, there is a lot of arsenic in the groundwater. Arsenic is a carcinogen as you all know, the problem is that much of this water is used in agriculture, so when it is applied to agriculture, part of the arsenic is incorporated into the plant and also into the soil, it

stays exposed to the wind, so the wind carries many of the particles of arsenic that could be inhaled, introduced to the lungs causing, well, in fact in the lagoon zone in Coahuila, it is already it is causing cases of cancer, not for smoking, but for inhaling particles that were originally in the aquifer and whose presence was induced into the environment.

Part of the work done here, I think in San Miguel de Allende, was the only municipality that took this problem seriously, in fact in 2004 they took the problem into account and did an analysis of all the wells of drinking water, including in the communities, 100 or more than 100 communities reported in all of these communities with concentrations of fluoride above 1.5 mg per litre which is the suggested limit by international and national norms, 1.5 mg per litre. Here in the watershed we already measured that in these communities the level is up to 5 mg per litre, from 2004 to 2012 we have measured 5 or 6 mg per litre, such as in the community of Tierra Blanca, for example, therefore showing that the levels of arsenic and fluoride are increasing, we are talking here about the impact only in the zone of San Miguel de Allende, at least more than 6 thousand people, consume water with concentrations higher than 2, it is practically pure poison in terms of fluoride.

The world health organisation recommends that the norm should be 1 mg per litre, because another problem associated with fluoride, that people don't often realise, is that damaging the neurotransmitters causes depression, above all among children and young people and in many cases it may result in suicide. In the United States they have found interesting correlations between high levels of fluorine and aggression or suicide. You all know that the state of Guanajuato has one of the highest suicide rates in the country.

These are the results from the municipality in 2004, here is San Miguel de Allende and this is the zone where concentrations higher than 1.5 are found, in fact, practically San Miguel, well, this part of San Miguel, towards the middle part has high levels of fluorine and these levels are increasing. In the most recent studies we identify the same chemistry of this water which is rich in arsenic and fluoride, that is the diagram that shows the concentration of bicarbonates, chlorides, sulfates, in this triangle, in this other one we have magnesium, calcium and sodium, so you can see that many of the points of chemistry of the same water are concentrated in bicarbonated water, a high content of bicarbonates and one component of sodium towards calcium, that is very important to see for ourselves the mixture of waters in the intermediate and deep systems. Part of the analysis was to see the groundwater, what was it found to be in equilibrium with? I told you that the water can reach great depths in its flow, until it contacts rocks and minerals that are 500 to 1000 or 2000 metres deep, the water enters an equilibrium with those minerals, therefore through this analysis we can know what kind of rocks the water is circulating around and in this case we see that the water for example is saturated with various minerals, they are minerals such as albite that is a fundamental mineral in volcanic rocks, arsenic, fluorite, they are clay minerals here and what this type of analysis tells us by using geochemical equilibrium models and that it is due to the type of rock that the water passes through, so I am not going to go into too much detail but it is important that you all know that this analysis of the chemical state has been done between water and the rocks that exist at great depths.

Another important aspect is that the water is extracted from the sub-soil, this groundwater is meteoric water, it is water that arrived from past rains, this graph that shows two isotopes of water, is Oxygen-18 and deuterium, if we graph the isotopic composition of the water in the world it would be along this line that we have here, for this reason it is called the world meteoric line, that indicates that the water that entered as rain, only that much of it, the black-filled circles correspond to ancient waters, from thousands of years ago and also rich in fluoride and arsenic, so we indicate that this water that has a normal trajectory related to rain water is not part of meteoric water but a closed watershed, etc., it is a bit more technical than that but it is important to mention that there it is also considered. Now, entering the part of the...like this show we all have a fingerprint, the water also has a very particular fingerprint or signature that once we identify we can trace past processes, in this case we have San Luis de la Paz, San Diego de la Union, Dolores Hidalgo and these lines here, they represent the arsenic concentration, here we have 0.02 mg per litre of arsenic, 0.04 up to 0.12m, norms suggest that the water has a concentration of 0.025 mg per litre and all the lines that you see on this side is water practically concentrated in arsenic, is practically poison, we have concentrations of .12 that are almost 40 or 50 times higher than the recommended level for human consumption and here what I want to highlight is that the water that does not contain arsenic has a signature based on this type of diagrams that show to the right hand side the concentration of chlorine, of bicarbonate, of sulfur, so when it has the peak towards the right, in this portion is bicarbonate water and when it is towards this zone it is salty (sodium salt), calcareous, magnesian, so you can see that the concentration is low but the type of calcium bicarbonate, while the water is rich in arsenic is water very rich in salts and bicarbonates and sodium, what this indicates to us is that the arriving water, the sodium comes from the dissolution of a potassium feldspar that is rich in volcanic rocks, so it arrives at the surface, just in the zone that they mentioned there is the greatest exploitation of the aquifer, in the zone of the greatest exploitation of the aquifer is where we now have the level at 150, 200 meters, it is where the deep aquifer water in the deep flow systems is now rising in density, it is hotter water, remember that we were saying that the water is hotter and if we put in contact the hot water with the cold water, the hot water tends to rise, so all these pollutants or these chemical elements that are in volcanic rocks in deep flows, with excessive water extraction, they are migrating for density to the higher parts, so this is extremely critical because... this would represent all the wells together that are in the granular aquifer and below the fractured aquifer that is where the water moves through the fractures that are volcanic rocks, so in the past there existed an equilibrium between cold water in the upper part of the first 400, 500 metres and below existed thermal water with temperatures higher than 50, 60 Celsius degrees, water rich in sodium, rich in fluoride, rich in arsenic, so when we generate regional cones of depression through the exploitation of these wells, it progressively generates an inverted temperature cone with water rich in arsenic, fluoride and sodium, so as the aquifer continues to be exploited, the migration of the polluted water will continue impacting different areas, this phenomenon is very important because we are also talking about whether or not it is feasible that there is recharge of the aquifer and at what point we should do it, we have to overcome a great quantity of water that is in the fractured aquifer and that is now migrating towards the surface, and that the only way to stop it is to prevent pumping in the basin, well, at least half of it.

Well, this brings us to various paradigms that we are analysing and really after 12 years, several questions that were asked of me in the morning were: what have they done about it and if it has had results?, well, the problem is that we can't begin solving the problems with the same mentality that created them, we have to modify our way of thinking and problem-solving, so what we have tried in these 10, 12 years is, with the same mentality that generated the problem, we try to find solutions and we have seen already that after 10 or 12 years this is not possible, well, Albert Einstein commented that we cannot resolve problems with the same thinking that created them, we are stuck at this part of the puzzle, so, these new paradigms are the following; 1. We have to incorporate and apply the theory of flow systems of groundwater to the function of the watersheds, their management and conservation, despite the fact that this system was derived from work in the 60's and that it has been perfected and to this date the Mexican authorities do not believe it, nor at a federal level, the funny thing about these systems is that they are perfectly tested with instrumental bases and analysis across the world. All countries now, the United States, Canada, Europe, European countries are now doing water planning based on the concept of water flow systems, why? Because it involves different timescales and only from these concepts and well, different residence times also, only from this knowledge it is possible to plan a sustainable system, any other way and we reach these critical concepts in evolution.

So this is a paradigm, we have to begin to understand the flow systems. Another, "the extension and geometry of the aquifers and not artificial limits such as political, artificial, state and municipal borders", well, in this watershed I told you about a granular aquifer that is the geological aquifer, that is only one, the state authorities manage up to two or four aquifers and in the past they managed up to eight aquifers, when in reality it is only one granular aquifer and they didn't even take the fractured aquifer into account, there for this is another paradigm than must be attended to, we cannot arrive at a solution for the problems faced if we do not recognize that the aquifers are the result of the geological evolution of the region.

And, well, by a certain part of the work that we did in the University the geometry of the aquifers are already integrated, their lateral limits, and also we have a mathematical model, it does not predict but it is useful when considering natural conditions and we are working with the migration model of this funnel of thermal water moving towards the surface. Which involves the fractured medium and the granular medium. The other concept is that "the groundwater is part of the water cycle where there are preferential movements vertically down in the zones of recharge and

ascending in the zones of discharge and other horizontal movements to the greatest lateral extension and these systems reach their equilibrium over thousands of years, they result from processes over thousands of years”.

So, this watershed was first exploited 60 or 70 years ago, and already the levels that we observe are practically the half the aquifer capacity, with this trend it is possible that the levels descend to greater depths, even though it is impossible to say: “The water will run out”, no, it will not run out, there will always be water for human consumption, the problem is what will be the costs and the technology required to clean the water? Agriculture will have to progressively cease, the same for industry, but there always has to be water for human consumption, the problem will be the costs, with all this process also of privatisation that is happening at a global level.

The other paradigm that we have to consider is that “the water has an age from a few days to hundreds or thousands of years and that recuperate the aquifer or to reach equilibrium, it could also include being far from the human scale”, many very interesting questions have been asked about the recharge of aquifers, about how to recharge the aquifer, we are going to see that it is not easy, but it is one of those themes that must be analysed, another is that the annual balance that is used, in fact there is a norm in Mexico to say water, the balance of groundwater is the water that filters through and is derived from precipitation, it rains x amount of water, 600, 500, 600 millimetres in one year which would be a column of water of this height. This means that 10 or 20 per cent recharges the aquifer and this is not true, we already saw that the age of water is in the thousands of years, we have done tests to infiltrate the 60, sorry 600 millimetres of groundwater, What do you think is the depth that the rainwater can reach in the subsoil in only one rainfall event? It reaches one metre deep, one metre, two metres deep, putting all the water together in one year, water obviously distributes itself during the rainy season in small quantities that sum up to 600 millimetres, so the deepest that the water can reach is in the order of one or two metres, if we have levels of 200 metres and it infiltrates at a velocity of one metre per year, you can do the math, therefore, the annual balance does not apply. And another thing is that “the equilibrium between the recharge and discharge in this aquifer has already been intercepted, the aquifer does not receive any recharge”. With the isotopic data of the ages and with the filtration velocity data, and well, the water chemistry is important too.

Another paradigm is that “there are chemical elements that are associated with flow systems that are bad for health and the environment that are progressively invading larger areas of the aquifer, impacting the health of the habitants and the environment”. There are zones in this watershed that were previously uncontaminated that now present high levels of pollution, in Dolores Hidalgo and San Diego de la Union, and, well, in San Miguel de Allende it is still growing, arsenic was not present here in the past, it has actually started appearing in many wells in San Miguel, and with facts from the authorities, these (facts) are not ours.

The other is “new paradigms mean new solutions”, we cannot plan the same sequence of solutions that we have been working with in the past, we have to establish new strategies for solutions and

for that well we have to generate and assimilate new knowledge, we have to prepare ourselves for many of the topics that I showed you earlier to be able to generate another mentality. Other criteria, including in many cases we forget what we traditionally learn in school and also to think that we should prepare with the new knowledge in the understanding of the problems and provide new and creative solutions, this is the way... and we can discuss and we can spend two or three hours talking about alternative solutions but I think that is not adequate. We take this to Congress, we take this to the Senator's Chamber, this publication that I am going to bring to you, a Senator from the State of Querétaro, we were working with them so that all this would be taken to the sphere of the National Water Law, also some changes at the Constitutional level of articles 27 and 28, passed unanimously in the Senate and was stopped in the House of Representatives so, it is extremely complicated, but this article that I will give you, there is another article which is in English, has this title, it is published in the journal Terra, we are going to bring it to you so that you have it. This is another of "the changes in the chemical quality of groundwater in the use of it in agriculture in the state of Guanajuato" (<http://tinyurl.com/n5wub4n>) where the quality of water in general the state is declaring, also this publication from the journal Terra with all the authors you see here and, in May of this year we are going to present in the AGU which is the American Geophysical Union, we are going to present a study of the watershed here, it is titled "The Sources of Water in this Watershed are not Sustainable", it is about sustainability but really it is a concept that is being managed inadequately, we are going to show them, and it has already been accepted and it is down to me to present it in one of the sessions of this title that is "Socio-hydrological interactions in an over-exploited aquifer with increasing concentrations of fluoride, arsenic and sodium", what I am telling you today I will present to the international community to show some additional elements to those which we just mentioned. And there is another theme too that we will talk about later, that is a local problem that we will also present in this congress of that we commented with Cesar... and well, this is the.. I'll end it there and I would like to hear your questions and to see if I am able to answer them.

Mauricio: Adrián, thanks so much, to continue we are going to have a moment of questions, we would like please that your questions be very succinct, we are going to have a maximum of ten.

Question: What minerals cause water to be very alkali? Because we are using water from a mine close to our house for our plants and it is very alkali, the plants won't grow. Which minerals, what is the cause of this?

Answer: It is just for the type, here is very important to show that San Miguel de Allende it is located in the exit of the watershed, that is to say that the majority of all the salts that dissolve from the higher reaches for all the corridor of the watershed until are concentrated here, ah, in Guanajuato, Capital! Guanajuato Capital is here, the problem is the rock type, the rocks are of volcanic origin and they have a mineral, two feldspars, that is a sodium, calcium aluminosilicate, so in combination with the water it forms, it bio-associates the bicarbonate and it is that which gives the alkalinity to the

water, it increases the pH, it increases the concentration of sodium in the water and that is what makes it alkali, the same happens in this portion of San Miguel, it is the rock type.

Question: Good afternoon. The water that we consume here in the city contains the same concentrations of fluoride and arsenic than in the same communities that you mentioned.

Answer: I don't know. I don't know, I think that would be better answered by the authorities that are charged with water here in the municipality, really we had sampled wells here from the potable water system and yes they registered high values for fluoride, but some of those wells were closed, they drilled new wells, I don't know if they have... I can't ... answer this precisely, I hope not.

Question: Have subsidence or fractures been caused by the pumping from the upper mantle?

Answer: The question is if there has been subsidence because of the extraction of water from the aquifer, yes, in fact, here note these lines, the hills, this is the San Miguel fault and you also see some rivers that are aligned, these rivers circulate around geological faults that have continuity in the subsoil, in this river, this part here, the aquifer also contains fine particle sediments, in terms of clays, that are very fine particles, so when these particles lose water for extraction that is occurring in this aquifer, the particles compact and effectively they are forming cracks in this part here of the aquifer of Dolores Hidalgo, they are forming cracks here in San Jose Iturbide, all this zone here that affect houses and there is ample industrial development in San Jose Iturbide and San Luis de la Paz that are generating cracks of large dimensions. The cracks are classified by micro cracks, cracks of decimetres, metres and there is already a new definition which are cow-sized cracks where the cows fall into the cracks, so, you can imagine the dimensions. In San Jose Iturbide there are already various cow-sized cracks that are continuous for various kilometres but yes it is a phenomenon similar to what is happening in Queretaro, Celaya and in the Bajio.

Question: Good afternoon. We would like to ask, I would like to ask you, can we first have this access to that which has remained inconclusive of the efforts of the political representatives? It is important to change this, there are also efforts that were made at another time with the water commission, the state water commission, the same SAPASMA, and on the other side, as you know there is the OCIDA that is an organization of rural communities in all the aquifer, the Dr. Adrian Ortego did not tell us but has been a promotor of legal representatives in these 13 years already because the first time that was presented this was in 2000, 13 years ago, this, finally. There are a series of organizations and we are going to help a lot for new projects that are being managed if with your competencies and your will you could indicated within the urgency that is left to continue driving at a legislative level, within your knowledge, what is left for us citizens also trying to manage that not only SAPASMA, CNA and the Consejo Estatal del Agua (State Water Board), but the municipalities that at times are not as democratic as we would like them to be, could we at least technically try to get closer to those arguments where ideas of new industrial centres or not, or where ideas of new general infrastructure or not, on the other side, also this with, in your experience of these thirteen years, with what other areas of the civil efforts... with academics and governments,

urge more that these four paradigms which are fundamental to bring us down to earth, I mean, well, I'm certain that in Tierra Blanca they are already working in questions of health for example... people that have to see to this..., but that others could be for that we are one way or another the citizens efforts with academics sometimes with governments we could bring? I think that behind the Charco we could have this, or the OCAS we could get this information that is important with your experience and knowledge over all things scientific, moral and I congratulate you, and going forward, you know that there are many citizens, we are with you Adrian.

Respuesta: Thank you, thank you, Arturo. Well, we have found with many related problems, O.K., this was a very rich study in all its meanings, from the scientific point of view there have been a series of understandings that we have not yet been able to publish and I think that is the first thing we must do. We have pending the publication of all the geometry of the aquifer, there is a mathematical model that is already being generated for initial conditions and we were working with Dr. Moyson of the University of Laval in Canada to model the ... to make previsions for the movement of this thermal system rich in arsenic and fluoride towards the surface, towards the cold, granular aquifer, so, this is a problem that is unique at a world level. We haven't found other places that know of this type of phenomenon, therefore we have, therefore we have been going little by little, but the first thing to do is publish all the data generated with the regional boards. We fixed the goal to produce the articles this year, of those which I mentioned a moment ago, there are around three or four articles that we are going to publish so that you have all the information condensed from the studies that we did. This is one part, the other is that we have to change the paradigms that we have seen that the politicians, the courses that we have given since the year 2000 as you correctly said, have generated this change in the way of thinking in the people, the most important is that they have put in action, more than that they are very dynamic groups of people, very concerned, that besides have a very important role in their areas of work in the municipalities... we want to offer a series of courses, another representative for example, we still don't know when it could be, perhaps we would focus more in the southern zone, that is to say a diploma in this zone, two diplomas there in the north of Dolores and perhaps we could open a diploma here for all of the public, to make a, to transmit all these understandings that we have achieved with these studies here, O.K, to continuing with this process and, since then all the information is already published, all the news that has been derived from this, there is a video on the internet that I suggest you review, put "Cuenca de la Independencia" and the video appears, it is interesting, I don't present photos of children with severe fluorosis that is too sad, the truth is that I don't like to do it, it is very sad, really I don't, I remember many things. So, we are going to try to establish a diploma because in addition many concrete questions have emerged about what to do? We open within the conclusions, we say around 20 or 30 solutions, none of these have been implemented, why haven't they been implemented? Because the way of thinking of the authorities has not changed on this matter. I want to comment that the members of the Cieneguita community, the problem that they have is that in a spring they just drilled a well, I don't know if you see this but it is totally ridiculous that the federal authorities, those responsible for caring for this aquifer, this system, this basin, have permitted the drilling of wells, O.K., of the 3 thousand wells that there are here, 1500 should not have been drilled, the problem that we have here is the 1500 wells, part of the solution is to close

1500 wells, so that those that are not closed, our mentality does not permit it, why are we going to close 1500 wells? Poor agriculturalists! Who is going to survive and who isn't? But 1500 wells are illegal here, they were drilled after the closure decrees, they are illegal, and, the well that was just drilled here in Cieneguita is a spring that gives around 20, 25 litres per second and they drill a well alongside, and this is what they are rightly fighting against. But this mentality of the people that should care for this aquifer from the technological and legal point of view, are the people who are violating the rules and all the principles, exposing the people of this watershed and they can say that in the centre and north of the country well they are violating fundamental human rights that are the access to drinking water and quality of life, so, well all that information we are going to put into your hands, in fact in CEDESA, already in the representatives that have given they have given the information, practically all the information that we possess and possibly with this idea we can now establish a bank of information, maybe here in the Charco, a bank of information with all this information that has been generated and that is available here for all the groups that are working towards this respect.

Question:

Good afternoon, my name is Santos Hernandez, I am not accustomed to these things that are happening, I see that there are many north Americans, why didn't you invite our authorities so that they see and feel what they have Cesar, please, Cesar has helped so much...

Pregunta:

The question is: What about water from gallon bottles? Are there problems with water quality or not? O.K. we in the university have done analysis of the water from gallon bottles, we did this in one moment but we found that almost the majority of the companies that sell water fill the bottle with a filter for bacterias, but lets through the arsenic, the fluoride, all the dissolved chemical elements pass through, those who have done much to this respect is the University of San Luis Potosi, in San Luis Potosi the University reviewed the chemical quality of all the companies dedicated to distributing water in gallon bottles and found that 90% of these companies had problems of quality with fluoride and arsenic, so they established a rule at state level so that the companies certify the water quality, but this is a risk that we do not know of in the watershed, we have done quality tests of water. I live in the watershed, we have done tests of the quality of water, I live in this part here and I receive in my home on occasions the double of the arsenic concentrations. I went to complain to the authorities and they sent me to hell! So, I have a system of filters to eliminate the arsenic, I also have a system of water collection and a solar treatment system, I am in the same situation as the rest of the people in the watershed.

Question:

The politicians tell us that the completion of the Realito dam will solve all of our aquifer problems and all our domestic water supply, could you give us some advice and some knowledge about that please.

Answer:

The question that Robin is making, Hello Robin, is related to the Realito Dam. The Realito dam is a dam that is in the last stages of construction in the states of San Luis Potosi and Guanajuato. I think the majority of the dam is in the municipal government region of San Luis de La Paz but it will bring water to the city of San Luis Potosi, it will bring water to San Miguel de Allende and to Celaya. There will be an aqueduct that will bring the water.

(Pointing to map) the Realito is here, it is here in this part, it is in on the borders of the states of Guanajuato, San Luis de la Paz and San Luis Potosi. So, there will be an aqueduct that will bring the water from San Luis Potosi, along about 100km of aqueduct and another one which will cross the watershed that will bring water to San Miguel de Allende and Celaya. An aqueduct especially to bring water here and to Celaya. There will be another dam here that will bring water from the Lerma Chapala watershed and take it to Guadalajara, (points to Guadalajara on the map) Guadalajara is here, and the other to Leon. These are aqueducts around 100 to 120 kilometers in length. (Correction from audience member, 140 km) – 140 kilometres. They {the government} gave the subventions to Spanish companies. One of these dams is Spanish, I'm not sure about the other one but it is not from here. The important thing is that this is the beginning of the privatization of water. It started when a group of people in the past, I can't give more details – that's another story, but... The problem is that we are following a wasteful mentality towards the element water. We are wasters. Already in this watershed there are 3,000 wells, 1,500 of which should not exist, which have caused a critical hydrological crisis in quality and quantity of water. Therefore, we generate a great water problem, and the solution is to bring water with big dams, causing great environmental damage, damaging many communities, for example they are going to destroy an entire small city in the case of Tamacapulin. And, on top of all this, a company is in charge of the cost of water. This company will increase the costs of water in such a way that water is changing hands to companies. In my point of view, the state should never lose control of the administration of water.

The other problem is that I don't know what will happen in the case of San Luis de la Paz, Dr. Mora already have problems with arsenic and fluoride, as well as San Jose Iturbide. What are they going to do with the aqueduct that comes to San Miguel de Allende – and aqueduct that goes all the way to Celaya? Will they have to put a soldier every meter to protect them? If they steal gasoline from the Pemex pipes, in the future I think that they will extract water from the aqueducts. So, Pemex is putting soldiers along their pipes so that people do not rob the gasoline, the same will happen with water in the future. The problem is central to the privatization of water that exists at the international level, and we should be forewarned that many of the solutions will not bring much if the same group of people are giving the guidelines.

