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PROCEEDINGS

WATER RELATED CONFLICTS OF INTERESTS IN THE ALPINE ENVIRONMENT - RESEARCH DEFICITS, DEMANDS AND SOLUTIONS

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1. INTRODUCTION

Within the „Austrian Network of Environmental Research“, initiated by the Federal Ministry of Science and Transport, a number of international workshops will be organized during the Austrian EU-Presidency in the second half of 1998. The above mentioned workshop is included in this line of scientific events and is considered as a part of special activities within the network entitled „Sustainable Use of Water Resources“. This workshop was offered predominantly for scientific, administrative and political experts from the European Community as well as from Switzerland, Israeal, Croatia and from Slovenia. The goal of the workshop was to transfer knowledge from a certain base level to practical applications in order to obtain a collaboration between science and administration.

This challenge was underlined by the speakers during the opening session. Mrs. Monika Kohl-Kircher, vice-mayor of Villach, expressed her hopes for a sustainable development of environment and economy in the Villach region. For the State Government of Carinthia, Mrs. Elisabeth Sickl listed a number of environmentally friendly projects in Carinthia, but she still called for a stronger incorporation of environmental aspects in the economic growth. From the side of the European Commission Mr. Panagiotis Balabanis (DG XII) explained the tasks of the fifth framework programme and its relation to the key action named sustainable water resources management and water quality. Finally, Mr. Wolfgang Reiter as the representative of the Federal Ministry of Science and Transport expressed the Austrian position in the water related Alpine research. Since the Alps are the source of several rivers flowing into large streams out of Austria, a transboundary view of water resources is essential.

October 1998

Hans Zojer
Abstract Water as a principal feature of Paradise, the Deluge as the punishment of sinful human beings, libations poured out on earth to flow into the transcendental world: an analysis of world-literature since the beginning of writing has shown various dimensions of water-related emotions divided into three main groups: 1) water as the first element which creates life, 2) water as a Purgativ, as a detergent both in a concrete and in a metaphoric sense, 3) water as a way of communication between this world and the transcendental one.

Scientists, civil servants and politicians responsible for and working on the field of water shall be reminded of these emotions, starting with a text by Heinrich von Kleist entitled “The Emotions in front of ‘At the Lake’ painted by Friedrich” by means of examples of worldliteratur. There is no element having a stronger symbol-meaning for humans and being especially related to emotions than water.

This approach to water based on the transcendental world is not less important than the scientific-technical approach, even if it lacks theories of explanations and knowledge, because the transcendental approach determines human thinking and behaviour, and so maintains the unity of man and world – unity which has risked of being destroyed since the beginning of modern sciences due to its analytic method.

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Only with this approach it is possible to explain the respect of water, which is necessary nowadays in order we do not waste and contaminate the “carrier” of life, which is water, and therefore not to cause the fall of mankind.

Introduction

On the 13th of October in 1810, an essay written by the famous poet Heinrich von Kleist entitled "The Emotions in front of ‘At the Lake’ painted by Friedrich" was published in the newspaper "Berliner Abendblätter". This essay is an extraordinary literary documentation for the emotional aura of a picture, in which the central aspect is water. The picture is entitled "At the Lake with a Monk", and the painter is Caspar David Friedrich. This picture does not exist anymore, because it burned down in Munich in 1931.

What remaind, however, are the emotions, which the poet Heinrich von Kleist had while looking at the picture.

176 years later, in 1986, the biochemist Erwin Chargaff published a book entitled "Serious Questions — An ABC of Skeptical Reflections"[^2], a collection of short articles ordered alphabetically according to their topics, like in an encyclopedia; in this book, you find a kind of counterpart to Kleist’s article, namely under the letter S: "Staying away from the Emotions in front of ‘At the Lake’ painted by Friedrich"[^3].

In this article, Chargaff deals with the loss of the relationship between modern society and the traditions of art in the past on the one hand, and on the other hand he talks about man’s incapacity of having such emotions concerning modern art, like with the picture painted by Caspar David Friedrich. — In this regard, the burning down of the picture gains a deeper meaning.

Nowadays, scientists, politicians and civil servants suffer from the same loss of emotions, when they deal with lakes, rivers and springs — to be short: with water. Therefore, this article aims at extending the historico-cultural content of this anecdote by adding a third part entitled "Memory of The Emotions in front of ‘At the Lake’ painted by Friedrich" —

[^3]: The title of the article in the german edition is: Wegbleiben der Empfindungen vor Friedrichs Seelandschaft
The Importance of Emotions in the History of Sciences

— because without emotions sciences and technology would lack success. Like the humanist Wilhelm Nestle writes in his basic work "Griechische Geistesgeschichte"\(^4\), it was in the 6th century B.C., when the hellenistic world did away with the old order of things — that order of things compulsory for everyone and considered to be divine. All of a sudden, man started to consider himself an individual responsible for himself and having to deal with his life and problems without any help of the gods. "I explored myself", writes Heraklit of Ephesos about 500 B.C. In other words, he used himself and his own perception and emotions as a basis of his cognition. Using this method he drew the conclusion that water is the starting point of the creation of life. He generalized this specific observation concerning water and he put it into one sentence, it says: *Panta rhei* — "Everything flows." This sentence is still valid because you can actually feel it.

Emotions are very essential for scientific and technological progress, too: Saint Augustin founded psychology with his "Confessions", in which he precisely explored his own complex soul. René Descart summarized his experiences in the sentence: *Dubito, ergo sum* — "I doubt, therefore I am" leading to the famous sentence *Cogito, ergo sum* — "I think, therefore I am". But this sentence could also go like this: "I feel, therefore I am."

Without such a high evaluation of emotions, sciences and technology could have never been successful; it is more than a loss of the historical dimension of mind, that these emotions are not accepted anymore in research, politics and administration, because emotions are felt to be a contradiction to the demands of modern sciences, which are "intersubjectivity" — once it was called "objectivity" — and "repeatability" — like in times when the social orders were based on mythology. It is the experience which makes us talk about the sciences as a myth and which gives scientists the same level of authority as the ancient priests had.

These emotions are to be brought back to the sciences and technology, in particular because biologists and psychologists — nowadays one of the most famous is Daniel Goleman, who published the marvellous book entitled "Emotional Intelligence", in which he used for first time the term

\(^4\) *Griechische Geistesgeschichte. Von Homer bis Lukian, in ihrer Entfaltung vom mythischen zum rationalen Denken dargestellt ..., Stuttgart: Kröner, 1944, S. 40ff*
"Emotional Quotient" or short EQ; this term is copied from the well-known IQ, "Intelligent Quotient", but Goleman used it as a contradiction — biologists and psychologists can explain in a plausible way, "that our innermost emotions, our passions and longing are essential for our survival and our species, the species man, which ows its existence mostly to the powerful activity of these emotions in the human world."

Emotions are to be brought back to the disciplines dealing with water, like applied hydrology, hydrogeology, hydraulic engineering, water-supply and distribution, and hygiene, as well as to those politicians' and administrators' minds who are responsible for those fields already mentioned. There is no element having more symbolic meaning for mankind than water and there is no element which is particularly related to emotions like water is. — To offer proof, let me remind you of the variety of mythological and literary water stories, in which emotions are collected and can be read about. These are emotions which, in the innermost parts of our souls, are still related to water.

The emotional Dimensions of Water

An analysis of literature from its beginning onwards shows a variety of dimensions concerning water and emotions, which can be divided into three main groups:

1) Water as the very first element, the creator of life
2) Water as a Purgative, as a detergent both in a literal and in a metaphorical sense
3) Water as a means of communication between this world and the transcendental one.

1. Water as the creator of Life

Water is the condition for life and as such it is eternal. Not even in the Bible, God has to create the water. Right in the first lines, it is described as without beginning and eternal like He is: "And the earth was void and empty", like it says in Genesis 1, 2, "and darkness was upon the face of the deep; and the spirit of God moved over the waters."

It is this water which God would use in order to create life: "These are the generations of the heaven and the earth, when they were created, in the day that the Lord God made the heaven and the earth: And every plant of the field before it sprung up in the earth, and every herb of the ground before it grew: for the Lord God had not rained upon the earth; and there was not a man to till the earth. But a spring rose out of the earth, watering all the surface of the earth." (Gen 2, 4-6)

Having soaked the ground with water, God uses the mud — in the Bible called "slime" — in order to form a figure, like an artist working with clay or children playing with mud — and he breathes life into that figure creating a human being.

In ancient cultures, for instance, in the Sumerian culture in Mesopotamia (about 4500 years ago) and then in the Akkadian and Babylonian cultures, water was considered gods — they were called Abzu (the freshwater) and Tiamat (the salt water) ―, but they were strange gods, inactive, idle, and almost helpless, until a powerful creator (for example, the Sumerian god Marduk or the God of the Bible) used them in order to create the cosmos and life. In Greek cosmology, like in Homer’s 14th book of the Iliad (lines 201ff), the water-gods Okeanos and Thetys create the generations of gods, but life as such — which is mankind — is created out of mud by Prometheus according to the Bible. Consequently, water cannot be considered devine: in ancient mythologies and religions, various water-gods and demons living in water do actually exist and they work with water, like causing beneficial and dreadful things, but there is no god in any culture who actually acts as water himself.

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6 All Quotations of the Bible from: The Holy Bible. Translated from the Latin vulgate, Baltimore: Murphy, 1899
This idea is still part of modern theories of evolution. In these theories, everything goes from the archaic atmosphere into water creating a kind of "soup" — the archaic ocean — from which life then can emerge. In 1990, professor Bernd M. Rode from the Department of Inorganic and Analytical Chemistry of the University of Innsbruck, found out how life could have emerged from this kind of "soup", from that archaic ocean. He discovered a chemical reaction in which, in a couple of days time, amino acid molecules coming from that archaic atmosphere are being transformed into complex protein molecules in salt water. This reaction is based on natrium chlorid ions and copper ions dissolved in salt water. These ions work as a catalyst. In other words, the soluble quality of water is an essential requirement for the creation of life; water itself, however, does not work actively.

Not only in the Bible but in ancient cultures as well, water is not considered to be God but it is God's element — eternal like He is. Consequently, it is only God who has water at his disposal. Without God's consent, man is not allowed to use it; and if God gives it to man, he will give this man the chance of survival, too. This idea is, to some extent, evident in Herodot's statement that the land Egypt is "a gift of (the god) Nile".

Therefore, water is the most important characteristic feature of those places called "Paradise". In hell, there is no water. According to the Genesis (2, 10ff) in the middle of the Garden of Eden, a river rises watering the Garden and then deviding itself into another four rivers. One of them is Euphrat, the other one is Tigris. Flowing out of Paradise, they surround Mesopotamia — the land between rivers, a land like Paradise due to the water's quality of making a dry land fertile and green. Today, along with the valleys of the Nile, the Indus and the Jordan, Mesopotamia is one of the most ancient cultural places in the world and it is still the most important field of work for water engineering.

In the Middle Ages, too, water was strongly related to the concept of Paradise, which is illustrated in Dante Alighieri's Divina Commedia,
Water related conflicts of interests in the Alpine environment

namely in the 28th Canto of the Purgatorio. In Purgatorio, the Paradise is the highest level of purification, and it is an obstacle to get over in order to enter heaven. Dante describes all his way up the mountain of purification, till he reaches a pine forest with a clearing full of beautiful flowers and a river marking the boundary to the wood. This river is the starting point for Dante’s description of the Paradise. It says (25ff): "... my further course a stream cut off, which tow ’rd the left hand with its little waves bent down the grass that on its margin grew. All waters that on earth most limpid are would seem to have within themselves some mixture compared with that which nothing doth conceal." The water of that stream is also lightful flowing through the darkness. Dante’s Paradise is bounded by such two streams like Mesopotamia is.

The water of those two streams is not earthly in origin, but: "but issues from a fountain safe and certain, which by the will of God as much regains as it discharges, open on two sides". Like in ancient cultures, in Dante’s medieval Paradise water is an instrument used by God.

Dante is told by a beautiful woman — she is the personification of Paradise, called Matelda — that God created this place for man "as hansel of eternal peace" (verse 93). This statement is still true today when keeping in mind what wars are being fought for water.

Water as the creator of life is just one aspect regarding God’s use of water. From the very start, God has used water in order to correct his creation which had gained some freedom. There is no mythology without naming the Flood or Deluge which kills those who have committed a crime against God. With this aim in view, God opens "the floodgates of heaven" as well as the "great depths" (Gen 11, 7f) so that the archaic ocean (which was devided into an upper and an lower ocean during the creation of the cosmos, Gen 1,7) gets the sinners. We have got a similar situation with the Sumerian myth of the Flood, which can be read about in the epos of Gilgameš: There, it is the two rivers of Euphrat and Tigris flooding the earth. Also in Greek mythology, only Deukalion and Pyrrha succeed in surviving the great Flood in an ark, like Noah did.

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in the Bible, or like Ziusudra did in the epos of Gilgameš; and they all become the pregenitors of a new and better generation of mankind.

2. Water as a Purgative

It is this destroying aspect of water which is related to the second group of the emotional dimensions of water: water as a purgative, a cleansing essence both in a literal and in a metaphoric sense.

The earth is being purified of all evil people by means of the Deluge in which life is drowned and washed away. There are not only global legends of floods but also local ones including stories about rich and arrogant miners who died in such floods, or including other stories about people who lost their possessions in a lake as a sort of punishment for their sinful lives. As an example, let me mention the legend about the formation of lake Seeburg near Göttingen where an Earl was said to be punished for his sins.12

In the ancient world, water was used as a means of washing away physical and ritual impurity. Purity is particularly important with the ritualistic act. In ancient Greece, the sacrificing person took a piece of wood out of the sacrificial fire, put it into a pot of water and sprayed himself, the people who were present, as well as the altar and the sacrificial animal.13 The holy water-fonts in catholic churches should remind of these rites. Years ago, such fonts did exist in houses, too. In front of a house where a dead body was laid out, there was a basin filled with water for the people to wash themselves because the corpses were said to be unclean.

An essence having a cleansing quality like that is of course to be worshipped. One of the rules of life the Greek poet Hesiod wrote down, forbids the passing of a river without praying beforehand and washing one's hands. The reason is that the gods are angry with those who haven't purified themselves of their evil characters.14

In the ancient world, whole cities and countries purified themselves by the use of water. In Greece, for example, at Apollo's feast, a criminal was

12 Deutsche Volkssagen, Wien: Zsolnay, 1992, S. 87ff
14 Hesiod, Opera, V, 737ff
thrown from the leucadian rock into the sea — a sort of Flood in which one, as a representative of the community, was washed away.

Even if it might be related to the biological death, the most essential aspect concerning the cleansing quality of water, however, is the aspect of life. A person is baptized and immersed into water in order to wash away his sinful body and finally come out of the font as a new man participating in the everlasting life. That means: only someone who has passed the gate of death — which, at baptism, is symbolized by the water — will gain eternal life. This is — God forbid — not a primarily Christian but a universal viewpoint. When Hindus wash their bodies in the river Ganges\textsuperscript{15}, this can be compared to ancient mythologies where "fontains of life" were said to give power and youth or revive assassinated people. In this case, the procedure is as follows: first, the flesh is put off the bones by cooking, then the bones are put on a cloth so that new flesh can be formed to create an entire new body. For example in Greek mythology, the same is said of Pelops who was killed by his father Tantalos in order to serve as a meal for the gods. The gods, however, refused to eat and revived the boy in the same way as mentioned before. His father was sent to the underworld and punished for thisatrocity with what is called the "torments of Tantalos": he is very thirsty but cannot drink because each time he gets down in order to drink the water which first reaches up to his chin, the water, too, gets down so that Tantalos in the end would never manage to drink it. As mentioned before: in hell, there is no water. This is one of its most important characteristics.

Again, as a most exquisite example of literature related to medieval ways of thinking, let me mention Dante Alighieri's Divina Commedia in connection with the cleansing quality of water. The two rivers, which keep Paradise within, are called Lethe and Eunoë. Lethe is also the name of the river which separates the underworld from the world of the living in Greek mythology. Before entering the realm of shadows, the dead person has to drink its water, which makes him lose his memory. When passing the river, he leaves his earthly life behind him, so to speak. With Dante it is different. He actually has to cross the river by diving through it in order to get into Paradise, but somebody drinking the water of the river Lethe only loses his memory concerning his evil and wicked acts. However, when drinking from the river Eunoë, his memory concerning

good and beneficial acts is being reinforced — this is a process which can be compared to the modern psychotherapeutic self-healing method according to the slogan of "think positively".

3. Water as a Means of Communication

Like man has to pass water like a gate in order to get into another transcendental and eternal world, in the earthly world, consequently he uses water as a means of communication with the transcendental world. In ancient cultures, there was no sacrifice or feast without what is called "a libation". A libation is an offering of wine or water poured out on earth in order to flow into the transcendental world and to create a link between men and gods.

This communicational aspect might be included also in the expiatory sacrifices, like with the example of the criminal being thrown down from the leucadian rock into the deep sea. This criminal can be considered a "message" to the gods, a kind of bottle post apologizing for all the crimes committed by the sacrificing community — even it that sounds macabre.

Another example for water as a means of communication between this world and the transcendental world is the story about Polykrates' ring, which Friedrich von Schiller put into a marvellous ballad. The story goes like this: Polykrates, tyrant of Samos from 532 to 522 B.C., possesses so much "fortune" (as Nicolo Macchiavelli would put it) that his friend Amasis, King of Egypt, warns him of the gods' jealousy. Polykrates, consequently, takes the most precious thing he owns — which is his ring — and throws it into the sea in order to appease the gods. The ring, maybe, is so precious to him because it is related to particular memories.

In this story, water is used for a communication between this world and the transcendental one in both directions, because the gods do not accept the present but send it back to him in the stomach of a fish.

Schiller's ballad closes with this event. The Greek historian Herodot 16 tells the entire story: actually, Polykrates' luck has a sudden end; Samos gets occupied by the Persians and Polykrates dies a cruel death nailed to the cross.

16 Histories III 39-43, 120, 122-125
The idea of water as a means of communication with the transcendental world leads to the opinion that water has to have a memory — how else should it be able to bring the messages to God or to the gods?

This idea — in a secularized and therefore symbolic way — is particularly expressed in love poetry, for instance, in the poem by Matthias Claudius entitled "At a spring":

"Oh, little green spring's light,
to thee my dear Chloe recently went,
with your waters so calm, so bright
and Chloe's face magnificent.
Oh, let her come to thy waters again
and keep her sweet countenance within;
I'll come to thee with my care
to mourn and oh so weak
because when I am with her,
my mouth doth not speak." 

This poem deals with the quality of water of memorizing pieces of information. The water, the spring, is asked to store the girl's face like a film which the lover is able to watch and talk to without the girl being there. The picture does not actually show the person but the main pieces of information about that person.

This idea is also the basis of modern homoeopathy. Some eminent scientists try to prove that water is really capable of storing information about the effects substances have, without the substances being in the water itself.

In the summer of 1988, the proof was done when 13 scientists from France, Italy, Israel, and Canada published an article about their experiment with its unexpected result in the famous scientific journal "nature". In their experiment, these scientists mixed immune globulin with water until the substance was gone. Not a single molecule was left; there was just pur water. According to the report, the water, however, did

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17 Matthias Claudius: Asmus omnia sua secum portans oder Sämtliche Werke des Wandsbecker Boten, München: Winkler, 1984, S. 708; German title: "An einer Quelle"
18 Translated by Ulrike Jaklitsch, Graz, 1998
19 Edition from Juni 30, 1988
show biological activities caused by the immune globulin — the same substance which simply could not exist anymore, in the water. The scientists concluded that the water (in order to be biologically active) must have taken over the information from the immune globulin. Moreover, they found out that the substance had changed its biological function according to the degree of dilution. During the process of dilution, the water had a series of "immune reactions" in a particular rhythm. The result of this experiment, therefore, would correspond to the ideas underlying homoeopathy. In homoeopathy, too, substances are being diluted or watered down so that the substance itself is gone. Nevertheless, the substance still works — so homoeopathists say. Now, the final result of this experiment was the scientists' attempt to prove that water has a sort of memory.

From a scientific point of view, the experiment was more than contradictory. A couple of scientists questioned the result and decided to do the experiment once again, under the same conditions and several times. But in each of their experiments, water did not have such a memory. — To be honest, I very much doubt that the sciences will ever be capable of proving a memory like that, for the simple reason that the idea of water having a memory (of any kind) is based on a view of the world which is beyond scientific reach.

**Conclusion**

Regarding Heinrich von Kleist's text "The Emotions in front of 'At the lake' painted by Friedrich" and other literary texts I mentioned, the point of this essay is that besides a scientific-technological approach towards water there is another one, namely an emotional, a psychoanalytical, a religious, and a transcendental one which is equally important even if this approach might lack theories of knowledge. This approach towards water is essential because it determines man's thinking and actions and, therefore, establishes man's unity with the world forever — a unity which has risked of being destroyed since the very beginning of modern analytic sciences. Only with this approach we can see how essential the respect for water is in order not to waste and poison the "carrier of life". Only in this way we can prevent the fall of mankind, which would not be a fall caused by the Flood but a final one, instead.

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20 *In this case "carrier" is meant as the combination of "to care for" and "to carry".*
Hydrological aspects of the 5th EU Framework Programme

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Water is an essential area for research where substantial progress has to be achieved in order to strengthen the scientific base needed to implement key European Union's policies.

Past and ongoing EC R&D activities cover a broad range of water related activities in order to provide the scientific basis in which appropriate policies for integrated water resources management have to be built. Under the 4th FP, water related research projects have been carried out in various specific programmes (e.g. Environment and Climate, Agriculture and fisheries, Industrial and Materials Technologies, Telematics for environment, International co-operation, etc.). Hydrological research has been a priority since many years in the context of environmental research. The current Environment and Climate programme includes studies on land/surface interactions and their role in the hydrological cycle, impacts of climate change on water regimes, surface and groundwater hydrology, forecasting of extremes events such as floods and droughts, water quality, and the ecological functioning of river systems, flood plains and wetlands.

The forthcoming Fifth Framework Programme of RTD represents a turning point in the history of European Union research. Explicitly conceived at the service of the European citizens, it is characterised by an orientation of the research activities towards the large social and economic issues Europe is facing, in support of the Union's policy objectives: improvement of European industrial competitiveness and the employment situation but also improvement of the quality of life of European citizens in its different dimensions, notably health, environment and security.

Hydrological research is going to be supported under the key action “Sustainable management and quality of water” which constitutes an

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21 Directorate General for Science, Research and Development, Climatology and Natural Hazards Unit
important component of the specific programme “Preserving the ecosystem”. Key actions reflect the new philosophy in FP5. They have to identify challenges or problems to be addressed through a multidisciplinary approach.

The key-action “Sustainable management and quality of water” aims to develop the knowledge and technologies needed for the rational management of fresh water resources, to contribute to the solution of water problems in order to optimise human and environmental benefits arising from healthy freshwater resources. Effective implementation and achievement of the anticipated benefits of this key action will require appropriate support for development, demonstration and dissemination activities and a closer involvement of the scientific community, industry, users and national organisations. The key action is proposed to be implemented by the following areas:

* The first area seeks to develop integrated approaches to understand and assess the status and evolution of freshwater resources in order to provide the knowledge and the technologies needed for the rational management of water resources with a view of meeting the need for the economic development of the European territory and the preservation of the natural environment. This area also focuses on the development of cost-effective pollution prevention, water treatment and remediation techniques.

* The second area deals with the sources, pathways, and behaviour of pollutants to identify, characterise and assess the quality of surface and groundwater and their impact to the natural environment in order to underpin the development of scientifically sound legal, economic, technological and management responses to the water pollution of EU-wide significance. The development and harmonisation of strategies and techniques for monitoring surface and groundwater bodies, as well as early warning and communication systems are also foreseen, in order to refine new EU regulations. Finally,

* The third area deals with the appropriate methods, technologies and strategies to improve the balance between water availability, water supply and water demand in order to combat scarcity of water and the lack of water of sufficiently high quality in water deficient regions.
Environmental Research in Europe

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The Joint Research Center, which constitutes the technical arm of the European Commission, consists today of eight institutes in five of the EU-Member Countries. With a staff of 324 people, the Environment Institute at Ispra/Italy embodied all the activities of the former Environmental Protection Programme which started in 1971 and today covers the thematic areas:

- Levels and fates of chemicals in the environment;
- The exposure of man and the environment to chemicals and their effects on both.

The mission of the Environment Institute is to provide independent scientific support to the European Union's sectorial activities and policies (which absorbs about 70% of EI's resources) and to provide as well, through its own research, a visible European contribution to international collaborative programs.

The EI's distinctive features are its European (non-national) status and its intrinsic multi-disciplinarity which allows the EI to operate in the fields of water research and monitoring, atmospheric processes and global climatic change, air quality control, environmental radioactivity monitoring, ecotoxicology and human health, environmental risk assessment and food quality and safety.

The Director of the Institute acted as co-ordinator of the "Environment-WATER" Task force established in 1996 on the initiative of the Commission with the goal to contribute to the definition of a European strategy on sustainable water use and to refocus scientific and technological co-operation on priority projects.

In the context of the 5th Framework Programme in the Environment Institute shall extend and broaden its activities in the field of water

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22 Joint Research Center, Environment Institute
research by establishing the European Laboratory for Water Protection (LEPE).

LEPE shall focus on water quality in European watersheds, the harmonisation of analytical methods and the improvement of environmental data quality, and the scientific support to regulatory activities.

LEPE foresees also the organisation of thematic observatories at European scale for example in the areas of European lakes, drinking water quality and emerging water research priorities.
Austria’s strategies in water policy

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Austria’s water management is characterised by constraints resulting from Austria’s geographical position being situated in and around the Alps. As a large part of the national territory consists of alpine regions, average population density (96 inhabitants/km²) and land use (~46% forest area) reflect this situation. Hydrological conditions profit from an average precipitation of 1170 mm/a. Nevertheless, bearing in mind that precipitation is spread throughout Austria unequally special measures have and had to be taken. On the one hand Austria’s water management has aimed to protect human settlements against the devastating forces of water, such as floods, debris floods or avalanches. On the other hand power generation could benefit from the excellent water resources and the orographic conditions. Nowadays hydro power plants generate up to 2/3 of electricity used in Austria. The other side of the coin shows that these activities also lead to morphological and hydro-morphological impacts on most of Austria’s rivers.

First of all Austria’s huge water resources determined a user oriented water-management. Due to the lack of water scarcity problems (only 3% of the renewable water resources were used) keywords like sustainable use or preservation of resources as used in international discussions were not of great interest. But water quality decreased as economic prosperity increased. Industrial production lead to a steadily increasing input of nutrients and pollutants. As a consequence water protection and preservation became additional basic principles of Austria’s water policy 4 decades ago. The two new main objectives were to preserve the sustainable use of water resources by protection and/or upgrading water quality to the level of nearly pristine quality and to protect groundwater aquifers in order to use them for drinking water supply. Measures to achieve these objectives were financed by governmental institutions for subsidies for water supply and waste water treatment (Wasserwirtschaftsfond) and the so called “Umweltförderung”.
All efforts together -amounting in annual expenses of 2% of the Austrian gross national product- were successful. Today:

- Austrian lakes have an excellent bathing water quality – and consequently drinking water quality
- Most Austrian large rivers show water quality class II of the sabrobic system
- 99 % of drinking water derives from groundwater resources mostly without any technical removal of pollutants

But Austrian water policy does not rest on its laurels. While maintaining the efforts above new challenges are lying ahead e.g.:

- Continuation of efforts to safeguard an overall protection of freshwaters in rural areas with special regards to the curbing of impacts due to diffuse sources water protection in rural areas especially in terms of diffuse pollution sources
- Search for resource friendly waste treatment, disposal and recycling (e.g. sludge)
- Remediation measures for old landfills

Precipitation, leaching, soil degradation and erosion may cause a high pollutant input into the aquatic system. Agriculture and water management should harmonise their activities to decrease the impacts of diffuse pollution sources. E.g.: In the eastern parts of Austria where the agricultural cultivation of land is high and the precipitation rate is low, groundwater aquifers in porous media are under pressure by nitrate and pesticides. In other cases surface waters can be affected by impacts due to erosion.

Scientific progress lead to new targets for water management. At present water authorities have to take account on the ecological functioning of surface waters starting from the existing heavy modifications of river structures. A close co-operation of institutions will be necessary especially in the field of hydraulic engineering, flood protection, hydroelectric power stations and ecology to develop viable solutions to reconcile their different objectives. In this context the (proposal of) Water Framework Directive will be the key instrument for water management in the European Community for the future. The framework directive requires that future water management must be river basin oriented with
special regard to the conditions and needs of the individual European river basins. The directive’s environmental objectives require that until year 2032 at latest European surface as well as groundwaters should achieve good status. Good status relates to good quantitative, chemical and in particular ecological status of a water body. Austria has the big chance to bring in already obtained experiences on a more holistic approach of water management in international activities, especially in the fields of future international tasks like within the River Danube Basin.

Consequently Austria’s further water policy will be characterised by:

- Safeguard the sustainable use of water resources and harmonise the needs of the different types of water use with special regard to the potential of renewable water resources and the demands of the ecological functioning of water bodies

- Preservation and restoration of close to pristine conditions of water resources to meet the demands of the different types of water use

- Protection of settlements against the jeopardy of water

The Austrian Water Act has enshrined the following principles of water policy:

- An overall and comprehensive protection of surface and groundwater throughout the country

- Precautionary principle to all surface and groundwaters, with special emphasis on the protection against dangerous substances

- Combined approach based on

  - firstly the control of pollution at source together with the reduction of the emissions due to the state-of-the-art

  - and secondly by setting water quality objectives with the obligation of taking measures in case of failing standards
Key elements for implementing the principles mentioned above are:

- Obligatory licensing for all kinds of water use (discharges)
- Compliance monitoring with internal and external control
- Control of water quality via the national network for monitoring water quality and quantity water quality network
- Obligatory remediation measures in case of not meeting quality objectives and emission limit values
- Obligatory adaptation of present discharges to the state-of-the-art
- Periodical assessment of achievements Austrian water quality report – yearbook on water quality and quantity in Austria, triennial report to parliament on freshwater protection in Austria

Since years Austria has been keen on establishing elements of the national way of water policy also in international contracts. Beside bi- and multilateral treaties with its neighbouring countries Austria initiated and supported the Convention on Co-operation for the Protection and Sustainable use of the Danube in the early nineties. This step highlighted the efforts to design further water management activities within an international river basin. The convention will come into force on the 22th October, being a milestone for the protection of the River Danube, taking care to preserve the sustainable use of the Danube and to set uniform quality objectives for all riparian countries. In context with the activities to protect the Black Sea the next urgent step will be to convene the level and extend of reduction of emissions with respect to the various natural hydrologic conditions and the progresses already achieved. Today Austria sees these tasks as a great, positive challenge of international co-operation. Austria is willing to contribute in a successful way by focusing all efforts and possibilities together.
Groundwater emplacement in European coastal aquifers since the late Pleistocene: Implications for development

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Abstract Most of Europe’s groundwater resources are found in sedimentary basins ranging from Mesozoic to Quaternary age. Throughout geological time these have been subject to flushing and replenishment with fresh (or saline) water in response to changes in hydraulic gradients brought about mainly by tectonic movement, sea level changes and other processes. Most recently the strong climatic fluctuations of the Late Quaternary have caused repeated rise and fall of sea levels, producing changes in hydraulic head and in patterns of groundwater flow both in coastal and adjacent inland areas. The impacts of these events on the present day configuration of groundwater in maritime Europe have been the subject of the EC-supported PALAEAUX project, involving partners from nine countries in a traverse from the Baltic to the Canary Islands. Recognition of palaeowaters and the interface between modern and palaeowaters has been obtained principally from isotopic and geochemical indicators supported by hydrogeological work, notably hydrogeophysical logging. In the present investigation a combination of tools is used to determine residence times of groundwater, palaeotemperatures and other paleoclimatic signals as well as identifying where modern waters may have modified these signals. For interpretation in a hydrogeological context, downgradient flow from outcrop is being studied in a number of aquifers where sequential geochemical and isotopic changes can be interpreted to provide relative timescales of groundwater emplacement and to constrain modelling studies.

The present day configuration of water resources and water quality is primarily the result of circulation of fresh water to a much deeper base level in response to lower sea-levels and/or to the direct impacts of ice-cover corresponding with the last glaciation. In northern countries there is evidence that recharge ceased during the last glacial maximum, but there is strong evidence that...
recharge was occurring during the preceding Devensian interstadial period. During the Devensian glaciation (122,000 to 12,000 years BP) average temperatures were 7-9°C colder than at present. Modelling studies by Boulton et al (1995) have suggested that hydraulic heads significantly above modern values would have significantly reorganised groundwater flow in ice-affected areas; some evidence to support this can be seen in some (but not all) of the aquifers investigated. However in southern Europe the same period was characterised by highly variable climate with contrasting wet and dry episodes (Zazo et al. 1993). Thus, over much of Europe, the exploitable water resources may occur to depths which are much greater than one would expect from present-day hydraulic gradients and recharge inputs due to effects on aquifers of the large fluctuations in climate experienced in the late Pleistocene and Holocene. These effects can be seen: a) in the porosity and permeability which have been enhanced by greater circulation during colder climatic conditions and; b) in the presence of palaeowaters which entered the aquifers and penetrated to greater depths than today due to increased hydraulic gradients responding to sea levels up to 130 m lower than at present.

Aquifers in coastal Europe are under severe pressure due to human settlements, industry and tourism. Although the reserves of freshwater in some near-coastal areas may be greater than hitherto realised, these waters represent a non-renewable component of the resource. Thus near boreholes drilled near coastlines may exploit a mixture of modern (renewable but often contaminated) water, palaeowater (which may be fresh or brackish) as well as a component of induced modern seawater.

These combined studies provide a background for ‘improved management of groundwater resources in the coastal regions. Palaeowaters in northern Europe generally represent groundwaters of good quality which are by definition free from human influences and which should be the subject of special conservation measures and appropriate usage. Routine measures should be adopted during testing and development to identify the interface between the modern and the palaeosystem. Palaeowaters are often located in lower permeability zones with poor yield and in such areas conditions may be suitable for aquifer storage and recovery schemes. In southern Europe, brackish palaeowaters are generally found and these may prove attractive as an alternative to seawater for desalination.
Introduction

Most of Europe`s groundwater resources are found in sedimentary basins ranging from Mesozoic to Quaternary age. Throughout geological time these have been subject to flushing and replenishment with fresh (or saline) water in response to changes in hydraulic gradients brought about by tectonic movement, sea level changes or other processes. Most recently the direct and indirect effects of glaciation, notably ice cover, permafrost and sea level change have induced changes in hydraulic head and patterns of groundwater flow both in coastal and adjacent inland areas.

The initial configuration of present day water resources and water quality, prior to human intervention has been primarily the result of circulation of fresh water to a much deeper base level (often marked by a saline interface) in response to sea-levels up to 130 m lower than the present day, and/or the direct impacts of ice-cover corresponding with the last glaciation. Thus over much of Europe, the exploitable water resources may occur to depths which are much greater than one would expect from a consideration of present-day hydraulic gradients alone. Evidence for deeper groundwater circulation can be seen: a) in the enhanced porosity and permeability especially in carbonate terrains and; b) in the presence of palaeowaters which may be recognised by a number of geochemical and isotopic indicators.

Aquifers in coastal Europe are under severe pressure due to human settlement, industry and tourism. In addition they are threatened by climate change and likely sea level rise resulting from global warming. As a background to improved it is important to have a good understanding of the processes governing their evolution, the initial conditions prior to exploitation and how they have responded to former sea level change. Reserves of fresh, unpolluted water in Europe may in fact be greater than anticipated from consideration solely of present-day heads and current recharge. This paper describes the methods and selected results for PALAEAUX an EU-funded project involving partners from Estonia, Denmark, France, Belgium, The Netherlands, United Kingdom, Switzerland, Spain and Portugal and which provides a transect across the present day and past climatic regimes of Europe. Although focused on coastal areas the results also have implications for other regions affected by glaciation and where palaeowaters may have been emplaced under different geological or climatic conditions.
The main scientific issues are:

I. can groundwaters be used as archives of former climatic conditions

II. what is the impact, extent and duration of lowered sea levels on groundwater movement

III. what was the impact in northern areas of ice cover and permafrost on groundwater emplacement

IV. what are the criteria for recognition of palaeowaters and what is their present day distribution

V. where is the interface between modern, pre-industrial and palaeowaters

Emphasis is placed here on problems related to the management of these resources and several issues emerge:

I. there is pressure on settlement, and development especially tourism in some coastal regions with associated falling water tables related to overdevelopment often involving exploitation of palaeowaters

II. deep drilling often intercepts both the modern as well as the palaeowater cycles

III. palaeowaters are a non-renewable resource

IV. there is a need to identify and prioritise palaeowater use

V. some changes may be needed in the administrative and legal framework in areas underlain by palaeowaters

**Methods**

The most compelling evidence for enhanced groundwater circulation during the late Pleistocene comes from geochemical and isotopic data. In the present investigation a combination of tools (including $^{14}$C, stable isotopes $\delta^{18}$O and $\delta^{2}$H, noble gases and inert and reactive inorganic indicators) is used to determine residence times of groundwater, palaeotemperatures and other palaeoclimatic signals as well as identifying where modern waters may have contributed to these signals. For interpretation in a hydrogeological context, cross-sections along flow lines from outcrop to depth such are chosen where possible so that
changes in geochemical indicators are more likely to indicate an evolution with time.

One of the problems of interpretation is that all, or nearly all, groundwater samples are mixtures, due to the fact that pumping integrates samples from different depths. Where there are multiple boreholes at the same site it may be possible to distinguish the relative depth of pumped samples on the basis of the relative temperature. Temperature and specific electrical conductance logs identify discrete levels of entry and assist provision of samples from specific horizons.

Results and Discussion

One aquifer cross-section from UK is used here (Figure 1) to illustrate results from the ongoing work. Using a range of methods but principally \(^{14}\text{C}, \delta ^{18}\text{O}, \delta ^{2}D\) and noble gas recharge temperatures (RT’s), the existence of groundwater of Holocene and/or late Pleistocene age has been proven both in UK as well as in all the regions of coastal Europe.

Aquiferes as archives of palaeoclimate and palaeoenvironment

Results show that information on palaeotemperature, past precipitation and recharge regimes as well as air mass circulation can be deduced from the geochemical evidence contained in the European coastal aquifers. One of the main deductions from the project is that an age gap can be recognised in some aquifers (UK and Belgium for example) which indicates that no recharge took place and thus that permafrost cover sealing was effective. In the East Midlands aquifer (Figure 1) where there is excellent \(^{14}\text{C}\) control no water ages are found between 20 000 and 10 000 yr BP. The stable isotopes \(\delta ^{18}\text{O}\) and \(\delta ^{2}H\) combined with noble gas recharge temperatures provide convincing evidence in aquifers from northern Europe that recharge occurred during the cooler climates prior to the last glacial maximum (LGM) and that recharge temperatures (probably equivalent to soil air temperatures) were some 6°C colder than at the present day.

In Estonia groundwaters are found with the lightest known isotopic composition in Europe. Groundwaters with late Pleistocene radiocarbon ages pumped from the Cambrian-Vendian aquifer have \(\delta ^{18}\text{O}\) values of –22 ‰ and must represent water recharged directly beneath the Scandinavian ice sheet. In southern Europe, the Aveiro of recharge through the LGM. Noble gas recharge temperatures also indicate that
atmospheric cooling of 5-5°C occurred before and during the LGM. However in contrast to northern Europe, an enrichment in $\delta^{18}$O of around 0.6 ‰ is found in the late Pleistocene recharge waters, and is considered to reflect the enrichment in the Pleistocene ocean water as well as the constancy in the source of moisture.

**Emplacement of groundwaters – depth and extent**

The base level controlling flow exceeded –100 m off the Portuguese coast as well as in the Atlantic islands (Gran Canaria), but in the Channel the maximum base level was –50 to –70 m and in the North Sea –30 to –50 m relative to modern sea level. A fresh-saline interface is found at depth in many European coastal aquifers above which freshwater of late Pleistocene age as shown by $^{14}$C has penetrated to various depths and is preserved in some of the larger aquifer systems.

In the UK East Midlands aquifer the fresh water has penetrated to the greatest recorded depth (about –500 m) and probably represents a continuous sequence of recharge since the previous high sea levels (over 100 000 years ago). It is difficult to explain this purely by lowered sea level and it is possible that greater heads imposed by the adjacent ice sheet at maximum advance has increased the depth of emplacement, supporting the models of Boulton et al. (1995). In Estonia, there is also evidence of colder palaeowaters to depths up to 250 m which may have a similar origin. In Denmark, which like the East Midlands was close to the stationary margin of the ice sheet, the Ribe Formation now contains water of Holocene age to around 200 m and any late Pleistocene water may have been largely displaced.

In all other regions, waters of Holocene age have been recorded. In the south coast aquifers of the UK, waters of Holocene age are found to ca 250 m in the Chalk. In the underlying Lower Greensand aquifer however fresh water of mid Holocene age (6500 yr BP) is found to –450 m depth near the coastline which is explained as recharge of Holocene age which was then slowed down or stopped by the rising sea level.
Implications for development

The development of aquifers in Europe and elsewhere during the past 50 – 100 years by abstraction from boreholes has disturbed flow systems that have evolved over varying geological timescales and inevitably boreholes penetrate time and quality-stratified aquifers resulting in mixed waters. A specific objective is to be able to recognise the extent to which waters from the modern (industrial) area have penetrated into the aquifers, often replacing palaeowaters. A range of specific indicators such as $^3$H and CFC’s may be used to detect this water influx but the human impacts may be more easily recognised as a pollution front from changes in the major ions, TOC, nitrate and trace elements such as B which are largely of anthropogenic origin.

In coastal regions where development pressures are already severe, many problems come together including issues relating to quantity and quality of water, seasonal demand, pollution risks and ecosystem damage. The water balance in many coastal areas is not fully understood and wells are drilled or deepened without the awareness that palaeowaters belonging to a former recharge regime are being intercepted. In many areas there is induced replenishment as modern (often polluted) waters are drawn in. However in some aquifers the rates of withdrawal exceed the natural recharge in effect a part of the resource is being mined.

In such areas there is a need for careful drilling to establish the age and quality layering as well as proper well completion. Correct management is needed often for seasonal demands – this may be beneficial, allowing winter recovery of water levels. The palaeowater however is a high quality resource and should be treated as a strategic reserve. It should receive priority for potable use and not be wasted for agricultural or industrial purposes which do not require waters of such high purity. Conservation targets are needed to allow for sustainability including ecosystem preservation. Changes may be needed in the administrative and legal framework to safeguard the use of the palaeowater reserves.

Acknowledgements

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Figure 1: Cross section through the East Midlands Triassic Sandstone aquifer showing the zonation of waters of different age and a saline fresh water interface at approximately 500 m depth. An age gap can be recognised between 10,000 – 20,000 yr BP corresponding to the absence of groundwater recharge during the glacial maximum. Prior to the glacial maximum recharge of waters some 6°C colder than at the present day can be recognised. At the present day, human impacts may be recognised by several inorganic and isotopic tracers including higher Cl.
ALPINE TOURISM AND WATER RESOURCES PROTECTION - REGIONAL CONFLICTS AND PROPOSED SOLUTIONS

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Geography

Slovenia is situated on a junction of the Alpine, the Mediterranean, the Panonian and the Dinaric geographic regions. About 40% of its territory belongs to the Alpine region, with the so-called high alpine area, peaking in the 2864 m high Triglav, not exceeding 15%. The rest of the Alpine region is a pre alpine mountainous and hilly area, further extending into the Dinaric region. The Julian Alps, the Karavanke Alps, the Savinja Alps and to a lesser extent Pohorje and some of the pre alpine and of the Dinaric mountain areas display an alpine character. They generally match with areas having by climatologic standards a mountainous or alpine climate and a corresponding vegetational cover. The alpine regions receive 1500-4400 mm of precipitation.

The topographic and climatic character of the alpine areas is resulting in a very low population density and in a lack of activities in the primary economic sector while the secondary and the tertiary sector, with tourism being part of the later, are then present.

Geology

Most of the alpine area, especially the high alpine one, is constituted of carbonate rocks, with pre Tertiary clastites being present in the Karavanke Alps, only Pohorje is formed of tertiary magmatic rocks. Mesozoic and Tertiary clastites take over the carbonates in eastern, hilly area of the Savinja Alps. Of the Alpine areas, the Julian Alps, the Karavanke Alps and the Savinja Alps belong geotectonically to the Southern Carbonate Alps and Pohorje represents an eastern extension of the Central Alps. Structurally, most of the Alpine and the Dinaric areas have a complicated overthrust or nape structure which is further complicated by Dinaric oriented wrench faults and their conjugate faults.
Hydrogeology

With the exception of Pohorje, made of impervious or poorly permeable rocks, all other alpine areas are formed of highly transmissive karst aquifers building the Alpine ridges and of highly permeable intergranular aquifers filling the deep Alpine valleys. A special type of Alpine karst has developed, with very high gradients and quick groundwater outflows. Occasionally, moraine sediments can be present both on the alpine plateaux as in the valleys, diminishing locally the permeability and protecting the underlying aquifers. In the alpine areas of the Dinaric region, being part of the High Dinaric Karst area, the differences in topography are less pronounced. The local discharge is oriented towards the Karst poljes and subsequently towards the tributaries of Sava, or rivers and springs discharging into the Adriatic Sea.

Water resources

Groundwater is the main source of drinking water in Slovenia. With the exception of the coastal area, most of the water in the areas with highest population density and economic activity is produced from Pleistocene gravel aquifers. Due to the advancing pollution of surface streams and of the Pleistocene and alluvial aquifers, the relative importance of the carbonate aquifers for water supply is growing. The same is true for the water resources of the Alpine areas. Their local importance was never compromised, but also their regional importance is now being considered.

The vulnerability of the karst aquifers of the Alpine area is very high, since little or no soil and vegetation cover is present, precipitation and infiltration are abundant and the related flow gradients are very high. It is different for some of the Alpine plateaux, where moraine sediments cover the karst aquifers and where marshlands and small surface streams may occur. These streams generally sink at the outside border of the moraine sediments area and the overall karst aquifer vulnerability is not really reduced. Water resources= protection within the Alpine area is a delicate matter and the water pollution load must be carefully controlled and prevented.
Protection of nature

Most of the Alpine areas are protected either as national parks, natural reserves or as protected areas. This protection is oriented against an excessive economic activity in such areas. Water resources= protection should result from the general protection scheme but practically, except for alpine lakes protected as specific water ecosystems, it is receiving limited attention.

Tourism

Tourism and the related economic activities represent 7.8% of Slovene GDP (1995). From about 90,000 permanent and temporary registered tourist beds, more than 10,000 beds exist in the Alpine areas. In Slovenia, three main types of tourist activities may be evidenced in the Alpine areas: 1) mountaineering, 2) sedentary, climatic tourism, and, 3) winter or ski tourism.

With about 100,000 overnight stays in 166 mountain huts, mountaineering represents an important tourist activity oriented towards the most protected areas of natural parks and reserves.

Sedentary, climatic tourism is mostly oriented towards the Alpine valleys and the corresponding lakes but also to alpine plateaux, where a medium high altitude and moraine cover resulted in an intense forest vegetation. Such plateaux are locally already intensively urbanized.

Of the Slovenian 1300 ha of equipped skiing areas with 120,000 skiers per hour capacity and 17 greater ski resorts, most are in the Alpine areas.

Regional conflicts

Mountaineering endangers water resources through an improper discharge of faecally loaded waste water. Further, the related waste dumps may be sources of additional pollution. Currently, it is not provoking important regional conflicts. Still, a potential for conflict exists since some resulting pollution has already been traced in springs not being used for water supply.

Sedentary tourism on the alpine plateaux endangers water resources in the underlying karst aquifers both directly and through the sinking surface streams. Cases were observed where spring water quality has
been affected or where a direct connection of a sinking stream from such an area with a spring used for the local water supply in the alpine valley beneath was determined.

Preparation of alpine ski resorts requires in the Slovene Carbonate Alps often a reshaping of the local topography. This does not directly impact the water resources. Here, the impact on water resources may be threefold: 1) through a change in vegetation cover, 2) through improper waste water discharge and waste dumps handling, 3) through an input of chemicals, generally fertilizers, used for the artificial snow preparation.

**Proposed solutions**

To achieve the desired water resources protection, the following must be done on a regional scale: 1) water resources of an alpine area evidenced and evaluated, 2) aquifer vulnerability evaluated and regionalised, 3) water resources protection zones defined, 4) tourist activity and facilities adapted to the required water resources protection standards.

To reduce the involved protection costs, we propose that in the areas without an economic activity, the aquifer vulnerability is just assessed but the protection zones very conservatively defined. If, subsequently, an emerging economic interest requires a local reduction in protection, the interested must pay for exploration allowing a less conservative definition of these zones.
Extreme runoff events in small Alpine catchments -
the need for early warning systems

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High magnitude intense storms and floods rank high in the list of natural hazards in an Alpine environment. Over the recent years, communities in several countries of the Alpine region have repeatedly been reminded of the devastating force of such events. In other instances, there has also been gained ample evidence that appropriate measures of prevention can very successfully contribute to reducing the loss of life and property. If properly supported by civil action, preparedness, and alarm plans, early warnings present a particularly well suited and effective measure to avert losses and to protect resources. As such, the development of early warning systems has gained increasing interest.

To be effective and reliable, warning of disastrous events must be based on a sound understanding of the processes that occur during these events and on a warning system that can accommodate the specifics of such events.

Extreme runoff events in small catchments are characterised by their individual character, their random occurrence, and their short-lived nature. These characteristics make it extremely difficult to forecast such events. Several aspects contribute to these difficulties: (i) even when it is known that an extreme storm will hit somewhere in a region, it usually remains unknown exactly where and when it will hit and which size it will have; (ii) observational data on such events are usually scarce which is due to the generally low network density of automatically recording raingauges, so local events are rarely recorded; (iii) the rare occurrence of extreme events reduces the chances of observing the important processes to close to nil and renders it difficult to provide the information needed for a thorough model building; (iv) detailed modelling of all the catchments of a region that are likely to be hit by a storm is not feasible, even taking into account the tremendous increase in information that has taken place with the advent of GIS and related techniques and instruments. From this it becomes apparent that routine hydrological modelling most likely will fail when applied to this task.
In this paper an alternative route to developing an appropriate hydrologic modelling strategy is proposed. It follows a two-step procedure using radar data in a first step to specify the current situation in terms of storm type and movement. The hydrologic response is derived in a second step using the information gained by the online radar observations as an input to so-called “catalogues” that link storm and catchment characteristics to the likely runoff responses.

Central to the proposed approach is the concept of “catalogues”. They actually act as a knowledge base that relates specific features of the storm and the runoff response to the factors that control their occurrence and development.

In the case of storm characteristics, it is the meteorological situation that dictates which storm features develop. Related to the meteorological development, storms of different types and structure (i.e. single cell, multicell, cell cluster storms, storms imbedded in squall lines, etc.) can be distinguished. In the catalogue of “storm types”, appropriate characteristics such as specific storm duration, intensity, temporal distribution, and areal-reduction factors are assigned to each storm type. It is this type of information that allows the definition of the current storm with its characteristics in a real-time situation once the storm type has been defined on the basis of the radar data.

In a similar way, a classification scheme for catchments has to be defined. The proposed scheme builds on the perception that storms of different types and magnitudes produce runoff hydrographs with distinct features and that these features closely correspond to the runoff mechanisms occurring during the event. The catalogue, therefore, is considered to comprise a set of typical catchment runoff response situations that are controlled by different dominating runoff production factors. In a real-time warning situation, the available information on storm and catchment characteristics is combined to determine the predominant runoff production factors and the corresponding runoff response.

Taking into consideration the extreme diversity of catchments and the different reactions of a particular catchment to different storms, it is obvious that the development of appropriate catalogues constitutes a major challenge. It is advocated in this presentation that the conduction of studies that are directed towards the comparison of observations in different catchments with various runoff producing factors may assist in the proper definition of the dominant factors that control the runoff
processes under extreme conditions. A “broader view” gained by collecting information for a variety of situations may assist in defining the crucial factors that influence the generation of diverse runoff responses.

To gain better insight into the mechanisms that characterise extreme events, as many of such events a possible should be analysed. Investigations conducted in Austria in recent years included the analysis of the scarce hydrometeorological data available, augmented by field observations that were directed towards the collection of auxiliary data based on various detectable traces of these events to develop a basis for the hydrological model building. By extending the number of cases that are analysed, a sound basis for the development of a process-oriented modelling approach can be established.

Model building for extreme events may then focus on the proper simulation of the particular factors that dominate extreme runoff behaviour in the catchment of interest. Simulation runs for a set of possible extreme storms and initial conditions may provide a range of possible runoff events that may serve as a basis for evaluating various warning situations.
Applications of Isotope Hydrology in Alpine Regions

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Abstract for more than three decades isotope hydrology has been used to study hydrological and environmental systems of Alpine regions. While in the initial phase the application of artificial tracers dominated, later the emphasis shifted to naturally occurring stable and radioactive isotopes, also known as environmental isotopes. The most frequently used environmental isotopes include the stable isotopes of the elements of the water molecule oxygen-18 and deuterium, measured as isotopic ratios $^{18}$O/$^{16}$O and $^2$H/$^1$H, and the radioactive hydrogen isotope tritium ($^3$H: half life 12.43 years).

The paper summarizes the principles of the application of these isotopes. An overview is given of the regularities in the spatial and temporal isotopic variations in precipitation of the Alps found through measurements of samples taken at meteorological stations included in the IAEA/WMO Global Network for Isotopes in Precipitation, known as GNIP, and in national networks of Austria, Germany and Switzerland. The spatial and seasonal variability of the isotopic composition of the winter snow pack at high Alpine elevation studied within the framework of the European project ALPTRAC, is also reviewed. Furthermore, field studies are reported which demonstrate the potential of environmental isotopes to (i) study the response of shallow Alpine aquifers to climatic changes, (ii) delineate recharge areas and protection zones of springs and other aquifers used for drinking water supply (the given case studies are related to the water supply of Innsbruck and Vienna), (iii) determine the residence time of water in such (karst) aquifers and in the catchment areas (of the river Danube), and (iv) estimate hydrological parameters of aquifers such as their storage capacity.
1. Introduction

For more than three decades, isotope hydrology has been used to study hydrological and environmental systems of Alpine regions. While in the initial phase the application of artificial tracers dominated, the emphasis later shifted to naturally occurring stable and radioactive isotopes, also known as environmental isotopes. This paper is related to the most frequently used environmental isotopes, namely the stable isotopes of the elements of the water molecule oxygen-18 and deuterium, measured in terms of the isotopic ratios $^{18}\text{O}/^{16}\text{O}$ and $^{2}\text{H}/^{1}\text{H}$, and the radioactive hydrogen isotope tritium ($^{3}\text{H}$: half life 12.43 years).

The spatial distribution and temporal variation of the stable isotopes $^{18}\text{O}$ and $^{2}\text{H}$ in the water cycle are mainly controlled by isotopic fractionation processes connected with phase changes of the water (evaporation, condensation, sublimation). Most of their applications in Alpine hydrological investigations employ regularities in their variations in atmospheric precipitation, i.e., in the input to the hydrological system under study. These regularities are manifested in the relationship between the isotopic composition of precipitation and the surface air temperature (temperature effect, seasonal variation) and the altitude (altitude effect), respectively (see e.g. [1]). Generally, the lower the temperature and the higher the altitude, the lower is the content of the heavy isotopes in precipitation (usually reported as $\delta$ value, the relative deviation of the $^{18}\text{O}/^{16}\text{O}$ ratio of the sample from the value of the standard). Typical values of the temperature coefficient and the altitude gradient of $^{18}\text{O}$ in precipitation of the Alps are close to 0.7 $\%$o per °C and $-0.2$ $\%$o per 100 m, respectively. Furthermore, through long-term observations carried out within the framework of the IAEA/WMO Global Network for Isotopes in Precipitation (GNIP), a good correlation was found between the inter-annual changes of the surface air temperature and the isotopic ($^{18}\text{O}$ and $^{2}\text{H}$) composition of the precipitation at European meteorological stations [1].

The radioactive hydrogen isotope tritium has been widely used because of the transient occurrence of bomb-tritium in atmospheric precipitation. The temporal change of the tritium concentration in precipitation, also called tritium input functions, is characterized by a pulsed-shaped function produced by the release of bomb tritium during the atmospheric hydrogenbomb tests in the late 1950s and early 1960s (see e.g. [2]). The tritium input function carried out at neighbouring stations included in the GNIP and/or other networks.
The stable isotopes $^{18}\text{O}$ and $^2\text{H}$ and the radioactive isotope $^3\text{H}$ have found a wide range of applications in studying Alpine hydrological systems. Often, only one of the two stable isotopes $^{18}\text{O}$ and $^2\text{H}$ is used. In general, however, it is more appropriate to measure both of them, because their relationship, expressed in terms of the so-called deuterium excess $d$ ($d=\delta^2\text{H} - 8\delta^{18}\text{O}$), can provide additional hydrological information, especially if the system under study is subject to evaporation. In the following, a few examples of recent applications of these stable isotopes and tritium are summarized.

2. Alpine hydrological studies using environmental isotopes

2.1. Response of shallow groundwater and rivers to climatic changes

Water supplies of Alpine communities are often fed by shallow aquifers which are potentially endangered by human activities (contamination, over-exploitation) and changes in climatic conditions. In an attempt to detect the response of a shallow aquifer (spring) and Alpine rivers in Switzerland to climate change, long-term observations of their isotopic composition were compared with variations in the isotopic composition of precipitation and in the surface air temperature [3]. In the study area, about 2000 m above sea level, the surface air temperature rose during the 1980s by approximately 1.5 °C and the $\delta^{18}\text{O}$ values of precipitation increased by about 1.5 %o (Fig. 1a and b). This climatic trend is also mirrored by the isotopic composition of shallow groundwater discharged by the spring First (Fig. 1c). The lower amplitude of the seasonal $^{18}\text{O}$ variations in the spring water and their slight phase shift compared to the atmospheric signal are due to changes in the infiltration conditions and the mean subsurface residence time of the water which, in an earlier study, was found to be between 2 and 4 years [4].
Fig. 2 demonstrates that also the two Alpine rivers Rhine and Rhone sampled at sites just before entering Lake Constance and Lake Geneva, respectively, carried an isotopic imprint of the observed global warming. The shift between the two $^{18}$O curves indicates that the discharge of the river Rhone contained 16% meltwater from glaciers (mean altitude 2130 m a.s.l.), whereas in the case of the river Rhine the contribution of glaciers (mean altitude 1800 m a.s.l.) was only 1.4%.
2.2. Water dynamics of the Upper Danube catchment area

Recently, long-term tritium (1961-1996) and oxygen-18 (1968-1996) records of the river Danube have been evaluated to derive information on the hydrological regime in the catchment area upstream of Vienna [5]. The measured tritium data of precipitation and Danube water at Vienna (Fig. 3) have been modelled in terms of the mean residence time of the water in the upper Danube basin. The best fit between the model calculations and the observed data has been obtained for a mean residence time of 3 years. The $\delta^{18}O$ values of the Danube appeared to be 1.5 %o lower at Vienna than at Ulm, Germany, indicating the contribution of Alpine rivers with lower $^{18}O$ content which enter the Danube downstream of Ulm. On the basis of the $\delta^{18}O$ values of Danube water and precipitation at Vienna the total runoff at Vienna, can be separated into three components: base flow, direct runoff from precipitation, and melting water. It has been found that the base flow constitutes more than 90 % of the total runoff during winter, and falls to ca. 50 % in summer [5].
2.3. Recharge and dynamics of groundwater

Schneealpe karst aquifer system used for water supply of Vienna

From 1967 to 1990, $^{18}$O, $^2$H and $^3$H were measured in about 50 outflows within a 9.7 km long gallery driven through the Schneealpe karst massif at the base of the carbonate rock [6]. While some waters of the central part of the gallery never exceeded a tritium level of more than 20 tritium units (TU), in marginal regions the tritium values went up to about 400 TU. These tritium measurements suggest that the mean groundwater residence time at the gallery outflows ranges from less than 1 year to about 80 years. The temporal fluctuations of the stable isotope concentration in the outflows were fairly small compared with the strong seasonal variations in local precipitation, but slight differences in the mean values of the various outflows were observed.

Since 1973, isotope measurements are also being carried out in the two major karstic springs of the study area, the “Wasseralmquelle” (Fig. 4) and “Siebenquellen”.

![Graph showing tritium concentration in spring "Wasseralmquelle"

**Fig. 4:** Tritium concentration in spring "Wasseralmquelle"
The tritium data of the spring water has been used to estimate the mean residence time in the fissured porous aquifer (low flow system), and the $\delta^{18}$O data has been evaluated in terms of the residence time in the channels of the karst system (fast flow system). The values obtained for the low flow system are 26 years ("Wasseralmquelle", Fig. 4) and 14 years ("Siebenquellen"), respectively, and for the fast flow system about 1 month for both springs. Knowing the total discharges of the springs, it was possible to estimate the discharge rates of the fast and the low flow component and the total storage volumes of the "Wasseralmquelle" (23.7 million m$^3$) and the "Siebenquellen" (19.1 million m$^3$).

**The Mühlau springs used for water supply of Innsbruck**

In the mountainous area from where the Mühlau springs rise (village Mühlau, near Innsbruck), the development of the touristic sector prompted hydrological studies aimed at the protection of this drinking water resource [7]. The water is tapped from the aquifer (karstified rocks of the Middle Triassic sequence) by a network of galleries at an altitude of about 1,150 m a.s.l., with the total discharge ranging between 600 and 1700 l/s. During 1989, water samples were taken from several outflows of the gallery and two springs to determine the composition of the water [7].

![Fig. 5: $\delta^{18}$O in Mühlau gallery outflows and springs](image)
From the δ¹⁸O values (Fig. 5) the mean altitude of the recharge area was estimated to be at about 1700 m a.s.l. The mean groundwater residence time of the various outflows and springs was derived from the tritium measurements, and the obtained values ranged from 5 to 15 years. This isotopic result has been interpreted in terms of the groundwater pollution risk and the storage capacity of the aquifers tapped by the outflows and springs [7].

3. Conclusion

The examples given in this paper represent only part of the wide field of isotope applications in hydrological studies of Alpine regions. These applications can be grouped as follows: (i) study of the response of hydrological systems to climatic changes; (ii) delineation of recharge areas and protection zones of springs and aquifers used for drinking water supply; (iii) separation of runoff components in catchment areas (hydrograph analysis); (iv) estimation of the mean residence time of runoff components in river systems; (v) estimation of groundwater pollution risk in connection with the use of bank filtration for water supply; (vi) separation of active from total storage in karst systems; (vii) determination of groundwater residence time to characterize the groundwater flow regime and pollution risk and to estimate the recharge rate and the storage capacity. In conclusion, it should be emphasized that isotope hydrology techniques are complementary to other hydrological approaches and thus became an integral part of hydrological studies in Alpine Regions.
References


I. Presentation of the Vercors

The Vercors massif lies in the Departments of Isère and Drôme (south Eastern France) between Grenoble and Gap. This karstic massif has a population essentially rural. During summer, the population increase with the arrival of tourism, and the request of drinking water becomes very important. More, in a few years the Vercors massif should become the water reservoir of border towns like Valence.

Geology: Vercors is a sub-alpine massif formed by series of anticlines and synclines oriented NE-SW. It consists of sedimentary rocks with a succession of limestones and marls mainly cretaceous with Miocene filling and quaternary (glacial) deposits.

II. Water problems

- resources/utilization
- tourism
- agriculture
- water for the big towns around Vercors
- pollution
III. The programme AGREAUALP: Agri-environmental measures and water quality in mountain catchments

AGREAUALP is an international, EU funded programme, with the following objectives:

- detection and description of the interactions between agri-environmental measures and water quality and resources, including groundwater, in mountain,
- analysis of the physico-chemical and biological processes of the interactions including the economical and social implications of the carrying out of these measures and the consequences on water resources,
- comparison of the impacts of agri-environmental measures on water quality and water resources in different alpine countries, Austria, France and Switzerland.

We have chosen pilot zones considering the following points:

- mountain zones, rural, in demand for drinking water, or being the catchment drainage basin of a river,
- rural zone where are or could be carrying out agri-environmental measures,
- zones where local collectivities and social groups have the will to participate to the project,
- zones where researchs have already be done.

The french site consists of four springs situated in the Vercors massif, 20 km south of the city of Grenoble, at a mean altitude of 1100 m. Each spring, consisting mainly of molass, has a well delimited small catchment area. Soil occupation is different on each spring (forest, culture, pasture and culture-pasture).

Hydrogeological characteristics: in this area, underground drainage is limited by the miocene mollasis deposits overlied by quaternary formations. The molass with the quaternary deposits constitutes a very porous environment.
The work done

A. Surface investigations under socio-economics aspects
   A1. Cartography of the land use
   A2. Agricultural structures and different mode of land use
   A3. Analyse of the water resource
   A4. Links between the different forms of land use and the environment
   A5. Socio-economic interpretation
   A6. Links between the environment and the economy

B. Subsurface investigations under hydrogeologic aspects
   B1. Analysis of the physiographic basin characteristics
   B2. Localisation of pollution risks
   B3. Longterm quantitative-qualitative observation of input and output
   B4. Allelopathy
   B5. Compilation and evaluation of the quantitative and qualitative data

C. Multidisciplinaty analysis of the results
   C1. Multidisciplinary analysis of the surface and subsurface investigations
   C2. Mediation of the research, the results and animation.

Recommendations and Regionalisation
1. to propose better land use and fertilization practices to reduce agricultural impact on water quality,
2. to study the transferability of the results in comparable alpine regions.
Research deficits in running water ecology

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Most running waters in Central Europe are severely impacted by various human activities. In their general overview of the alpine region, MARTINET and DUBOST (1992) document that only approximately ten percent of river reaches can be classified as “near natural”. Based on the vegetation studies of MÜLLER (1991), only fragments of the formerly large braiding river systems are preserved. An recent investigation of the 52 largest Austrian rivers with a catchment area > 500 km² provides a nationwide survey of the ecological status quo of Austrian running waters and may serve as a representative example of the current status of running waters within the European alpine region (MUHAR 1998). Using evaluation criteria that consider the 4-dimensional nature of running water systems, the study shows that about 80 % (3,900 km) of the Austrian river stretches have recently been moderately to strongly impacted by human activity; only about 20 % still show high habitat integrity and have retained their essential natural functions.

Since most Austrian running waters with poor water quality have been significantly improved during the last years, major deficits in ecological integrity are now due to various river engineering measures. Especially flood protection measures and hydro-power plants severely degrade aquatic habitats. Besides creating monotonous aquatic environments, the latter often generate problems connected with water diversion, hydropoeaking, flushing of impoundments, etc..

Because of the deficit of ecologically sound running water systems, a major target for the future development of the alpine region must be to assess and protect those running waters that still retain their natural environs and functions. Additionally, in accordance with the EU Water Framework Directive, special attention must be paid to research on assessing ecological integrity and its impoverishment by human alterations. Special emphasis should be given to impacts on the aquatic biocoenoses caused by human-induced hydrological disturbances (impoundment, water diversion, hydropoeaking, flushing) as well as channelization and habitat fragmentation. A further key issue of the future will be global climate change and its various effects on the physical environment (e.g. water temperature, discharge regime) of
aquatic organisms. Such increased knowledge is the vital basis for adequate restoration/mitigation strategies leading to the development of running water systems that regain their type-specific features and ecological integrity.
3. WORKSHOPS

**Workshop 1:**

PRESENT LAND USE PRACTICES AND ASSOCIATED WATER PROBLEMS

**Concepts:**

ROBERTO JODICE

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**Abstract:** The present agronomic practices deeply influence the water quality, both superficial and groundwater, and for this reason the European Community in December 1991 issued the „Nitrates Directive“, with the objectives to reduce water pollution caused by nitrates from agricultural sources and to prevent further such pollution.

The theme is also valid in the alpine environments where, in the past years, techniques and practices already experimented in the plane regions, have been introduced. The aims of these techniques and practices are to maximise the productive yields, to get profitable the cultivation, even by the concentration of the activity in the most favourable zones.

These aspects involve all the different sectors of the agriculture (breeding, herbaceous culture, fructiculture ecc.), frequently with negative reflections on water quality. The presence of organic and inorganic contaminants (such as fertiliser, pesticides ecc.) in some waters of alpine environments is well documented.

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--- 23 Conveners: Roberto Jodice, Eduard Klaghofer
Participants: Daniel Bogner, Laurence Bourjot, Barbara Cencur Curk, Gerfried Eder, Gerhard Freundl, Gerhard Kuschnig, Albrecht Leis, Norbert Plass, Miran Veselic
Moreover the urban settlements add further contaminants to the same waters, often because of the difficulties of wastewater treatment, due to climatic or morphological reason.

Therefore it is pointed out the abandoning of less favourable zones, with associated problems of runoff, erosion ecc.; from the other side the concentration of urban and agricultural settlements, mainly at the valley bottom.

It is necessary to carry out studies and research of the alpine environments, with the general aims of identifying the sensitive and vulnerable zones, and planning the future urban and agricultural settlements.

The speaker will introduce some agronomic practices, suitable for the alpine environments: grazing, grass establishment, cover crops, new techniques in fructiculture, with the objectives to improve the quality of the crop, and to decrease the environmental impact of the cultivation, with special regard towards water quality protection.

Land application of fertilizers

**PERIODS WHEN LAND APPLICATION OF FERTILIZERS IS INAPPROPRIATE**

Nitrogen fertilisation with inorganic fertilisers is a practice adopted for all nonleguminous crops. In order to use this type of fertiliser to its best advantage, it is necessary to administer the nitrogen fertilisers as near as possible to the moment when it will be used by the plants. In this way the danger of the nitrogen being leached during the period between administration and use is effectively reduced. The use of nitrogen fertilisers is specifically based on the principle of the crop making the best possible use of this type of fertilisers while at the same time, minimising loss by runn-off.

Where animal waste is used, it is important to remember that the amount of nitrogen available to the plants in slurry depends on the different types of nitrogen presents in the slurry. The forms which are readily available are nitric and ammonium; more can be made absorbable following a mineralization process of the organic compounds.
Compared with organic fertilisers the efficiency of the total nitrogen from slurry during the year of application is estimated to be an average between 50 and 70%, with values increasing for cattle, swine and poultry manure.

Recommendations

Crops with long growing seasons – autumn/spring (e.g. wheat or similar cereals, rape, grasses): nitrogen fertilisation should never be carried out during the sowing season. Crops should be top dressed when fertiliser is most needid i.e. during the different phases of flowering and just before shooting.

Perennial crops (fields, pastures, grassland, woody, year round vegetables: application should be effaced just prior to the reprise that signals the start of the period of heavy absorption.

Spring sown crops (potatoes, vegetables): nitrogen fertilisation at sowing is acceptable because of the short space of time that elapses between fertilisation and absorption. But if the rainfall is high amounts of fertiliser used should be split or the fertiliser used should be a slow transfer fertiliser with the addition of nitrification inhibitors.

If livestock manure is used distribution should be carefully planned to meet the physiological need of the crop at the appropriate time and should not be distributed to comply with demands on the storage containers. In this case application to arable land is advisable between the end of Winter and the beginning of Summer.

APPLICATION OF FERTILISERS

Mineral fertilisation

Fertilisers can be applied either to the entire surface of the soil or localised, with or without burying in both cases. As a general rule, fertiliser application should affect only the depth of the soil probed by the root system of the crop.

Apart from the technical solutions adopted and the physical characteristics of the fertiliser used, the application system chosen must be one which allows the fertiliser to be distributed uniformly and evenly both as the machine advances (longitudinal uniformity) and perpendicular to the machine (cross uniformity of distributions).
In order to avoid unnecessary distribution that is negative, both in terms of environment and expenditure, particular care should be taken in the application of fertilisers on plots surrounded by drainage ditches or other features that form part of the waterways in close proximity to the edges of the fields.

**Livestock manure**

Distribution techniques for livestock manure have a considerable influence both on the environment impact of the manure (water and air pollution) and its productive efficiency.

Slurry is usually top dressed by means of thanks, which are either towed or self propelled, mainly operating under pressure, and which are used both for transport and distribution.

Distribution by conventional criteria can mean not only a lack of evenness of distribution but also the emission of ammonia and other products responsible of odours. This occurs either because of the atomisation through jets or more often because of the amount of time the slurry remains on the ground.

Recommendations

In order to avoid or to reduce the above mentioned problems, it is necessary, wherever possible, to make use of new distribution techniques such as:

- Separating transportation and spreading of the slurry
- Burying via injector equipment
- Top dressing with low pressure equipment

**LAND APPLICATION OF FERTILIZERS TO SLOPING GROUND**

For the correct application of fertilisers to sloping land, the most important factor to take into account is the risk of surface run-off which is mainly dependent on the following:

- Gradient of the ground
- Characteristics of the soil
- Type of landscape
- Crop system
- Climatic conditions
Techniques used to control the erosion can resolve pollution problems caused by N and P even though they may have a grater effect on losses of eroded materials than on losses through run-off. However they have no effect at all on the nitrate leaching and can sometimes aggravate the situation.

Reduced cultivation of the land maintains residues on the surface so reducing erosion and conserving the soil.

Pollution of water by surface run-off is difficult to avoid when there is rainfall and under these circumstances it make very little difference whether the fertiliser applied is of a chemical or organic nature. Application of fertiliser should be avoided at times when run-off is likely. For fields, pastures and for untilled lands in general, this is a very important factor.

- **APPLICATION OF FERTILIZERS TO WATER SATURED, FLOODED, FROZEN OR SNOW COVERED GROUND**

Distribution of fertiliser on water saturated soil during the winter would be of very little use since a considerable amount would be lost through denitrification.

When soil is either frozen or is completely covered with snow, fertilisation should be avoided.

- **APPLICATION OF FERTILIZERS TO LAND ADJACENT TO WATER COURSES**

The good agricultural practices to be adopted in order to effect the correct application of fertilisers on land adjacent to watercourses include:

- A reduction in the use of nutrient substances in solution to be absorbed in the soil particles
- The creation of intermediary streams to slow down the flow towards surface and underground waters
- A reduction of the speed of surface water flow obtained by increasing the roughness of the land and the amount of surface drainage, as well as by reducing the surface gradient.

Especially useful for these particular plots of land, in term of controlling the run-off is the use of cover crops during the winter season and the conservation of vegetal waste on the soil surface.
Land management

• CROP RATATION

It is advisable to avoid single crops or Spring-Summer crops that leave the ground uncovered from Autumn to Spring.

Crop rotation which are most in keeping with the aim of reducing loss by leaching are those which ensure coverage of the soil during the rainy season: winter cereals, in rotation with other Autumn-Winter crops (rape, grasses, crucipherses ecc.).

• MAINTENANCE OF COVER CROPS

A plant cover prevents the accumulation of nitrates through absorption by the roots. Possible vegetation coverage can be achieved by the following:

- Spontaneous vegetation: natural grassing over which occurs at the end of summer autumn after harvesting of a crop should be regarded very favourable in high-risk areas as a means of controlling the leaching of nitrates.
- Intercalary crops, between the harvesting of the crop and the sowing of the next
- Catch crops, which have no final use but which serve only to intercept the soluble Nitrogen (“controlled grassing over”)

• TILLAGE AND STRUCTURE OF THE SOIL

Grassing over is particularly effective when it comes to reducing surface run-off on sloping land thus preventing the supply of nitrates in surface water bodies.

In addition the soil is less likely to allow the water to infiltrate because of its greater storage capacity.
Prevention of water pollution

• FROM RUN-OFF AND DRAINAGE IN IRRIGATION SYSTEM

Irrigation can contribute to water pollution through the movement of irrigation water either vertically from the surface to lower layers (drainage) or horizontally by surface run-off.

For example the irrigation method by surface flow is not advised in areas at high or moderate risks: irrigation by spraying is applied in order to avoid loss of nitrates by leaching or surface run-off.

Management of livestock

• GENETIC IMPROVEMENT
• FORMULATION OF DIET

Management of stock farming effluents

• ANIMAL HOUSING
• EFFLUENT STORAGE SYSTEM
• TREATMENT OF EFFLUENT
Following structure will be chosen at the workshop and topics will be discussed:

- **Definition of Alpine zones, especially in Austria**
- **Natural conditions under the aspect of landuse**
  - climate
  - geology
  - soils
  - natural vegetation covers
  - agriculture
  - forestry
- **Impacts on the environment associated to water problems**
  - air pollution (influences on vegetation, soil, groundwater)
  - human impacts: tourism’s (skiing, mountain biking, etc.)
- **Conflicts of interest between**
  - agriculture
  - forestry
  - tourism’s
  - energy production
  - drinking water
- **Research deficits**
  - land Resource Inventory
  - definition on Potential Landuse and Suitability (Criteria)
  - definition of Conservation Needs (under consideration of socio economic factors and integration soil conservation with landuse)
  - land Capability Assessment (classification)
  - quantification of impacts on landscape and productivity:
    - e.g. changes in water quality
    - increasing
    - declining crop productivity etc.
- **Solutions**
  - Evaluating Management Actions
Results of Workshop 1

The participants considered and discussed the main landuse practices associated to water problems in alpine zones.

Firstly the discussion started with the definition of alpine zone, as mentioned in the “Alpine Convention” and the urban settlements supplied by mountains waters.

The landuse considered were:

- Agriculture
- Forestry
- Urban settlements
- Industry
- Tourism
- Infrastructures

For that concerning agriculture, the participants considered very important to apply good agricultural practices for reducing water pollution, as imposed by EC into the “Nitrates Directive” of 1991.

The participants pointed out that the agriculture practices in the mountains areas do not influence considerably the nitrate levels of drinking waters, but some problems could arise from faecalic microorganisms, ammonia and other parameters. In some valleys the ground water quality is seriously affected by nitrate.

Urban settlements and tourism activities could add further contaminants to the same waters, due for example to the difficulties in waste water treatments, solid waste disposal ecc.

It is necessary to carry out research, studies demonstrative action with the general aim for identifying the sensitive and vulnerable zones, at different scales.

The main fields of such activities were considered:

- soil functions and soil conservation
- climatic charateristics (rainfall, ecc.)
- hydrogeology and water balance
- ecosystem
- socio-economic aspects related to landuse
- suitable agricultural and forestry practices related to water protection measures
Useful tools are the multidisciplinary studies of the landscape at regional levels for carrying out:

✓ soil maps ✓ vulnerability maps
✓ ecosystem modelling ✓ capability maps
✓ vegetation maps (actual and ✓ landuse maps potential)

It was underlined the importance of long term data collecting, for on-line monitoring the evolution of land use practices and for delivering to local governments precise knowledge of the territory for its future sustainable use.

Long term land use studies related to water quality aimed at preditional parameters sensitivity analysis should be carried out as a multidisciplinary research programme. The best way is to proceed through an international concerted action, so that a series of environments and landuse can be analysed simultaneously and the corresponding research time reduced.
Workshop 2

Water-related conflicts and sustainable water utilization

Concepts

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1. Introduction

➢ Typical water-related conflicts (present and future) with their multiple aspects (hydrology, environment, social, economy etc.) : some real examples.

➢ Criteria to assess priorities in water utilisation in the concept of sustainable development

➢ towards a charter for ethical rules

2. Discussion on a project of charter (distributed before workshop)

Corrections and complements to the draft.

3. What could be a strategy for an acceptance of the charter by mountainous countries

Discussion

24 Conveners: Aurèle Parriaux, Uwe Herzog,
Participants: Jean F. Dobremez, Wyndham M. Edmunds, Ilse Entner, Markus Forster, Peter Hacker, Hermann Häusler, Georg Martischnig, Gunther Suette, Eliyahu Wakshal
UWE HERZOG
Amt der Kärntner Landesregierung, AUSTRIA

a) Generell:

Gemeinsames Spannungsfeld zwischen

**Dargebot**

- Erfassung
- Erhaltung
- Schutz (rechtlich, praktisch)
- Bewirtschaftung
  - Wasserwirtschaft regional
  - Wasserwirtschaft national

**BEDARF**

- derzeit / prognostisch
- Reduktion unter Beachtung von
  - Vorgaben und Zwängen

- v.a. vom „Entwicklungsstand“ des Verbrauchsgebietes abhängig

Wechselwirkung von

**Hydrologischer Bilanz**

Dazu bedarf es

- wasserwirtschaftlicher und rechtlicher Festlegungen
  - v.a. Entnahmekriterien/ -mengen
  - (auch Rückführung und Anreicherung)
  - Verteilung
  - Schutzmaßnahmen
  - Entschädigungsleistungen
  - Interessensausgleich
  - Kontrollmaßnahmen / Wasserinformationssysteme

aufbauend auf wissenschaftlicher Grundlagenerhebung

wasserwirtschaftlicher Ergebnisumsetzung und

sozialer Akzeptanz
b) Water-related conflicts

ergeben sich grundsätzlich aus:

- Mißverhältnis zwischen Dargebot und Bedarf (v.a. quantitative Probleme)
- Konkurrenz zu anderen Raumnutzungsansprüchen (qualitatives und quantitatives Problem)

Im alpinen Bereich verschärft durch den sehr begrenzt verfügbaren Raum!

Wesentliche Konfliktbereiche:
- Land- und Forstwirtschaft
- Siedlungstätigkeit
- Massenrohstoffgewinnung / Bergbau
- Industrie und Gewerbe
- Tourismus und Freizeit

jeweils als Nutzer mit unterschiedlichem Bedarf an Wasser und Gefährder als Belaster mit Abwasser und diversen Schadstoffen.

c) Sustainable water utilization

Grundfragen: c1) Was sollte man unter “nachhaltiger” Wassernutzung verstehen?
   c2) Wann ist diese sinnvoll?
   c3) Wo ist sie sinnvoll?
zu c1) Versteht man darunter
Zukunftsorientiert?
Dargebotsschonend?
Bedarfsdämpfend?
Sparsam?
Optimierte bewirtschaftet / rationell?
Sorgsamer Umgang mit Wasser?
Stete Gewährleistung der Versorgungssicherheit unter Berücksichtigung obgenannter Kriterien?

zu c2 und c3)
Hohes Dargebot qualitativ hochwertigen Grund-/Trinkwassers (abhängig von Hydrologie, Hydrogeologie u.a. naturräumlichen Gegebenheiten) ermöglicht u.a.

- entscheidenden Beitrag zur Lebensqualität und Volksgesundheit (Hygiene)
- entscheidenden Beitrag zur industriellen/wirtschaftlichen Entwicklung
- entscheidenden Beitrag auch zur Erzeugung gesunder Lebensmittel.

Daher hängt die Entscheidung des Wann und Wo wesentlich von der Betrachtungsweise und den regionalen Gegebenheiten ab.

Wesentliche Aufgaben zur Zielerreichung einer optimierten/nachhaltigen Nutzung kommt der Wasserwirtschaft/Politik zu:

- Besinnung auf Werte des Wassers
  - Erhaltung des natürlichen Lebensraumes
  - Wasser ist das Lebensmittel
- Wasser als Steuerungsinstrument der Raumordnung
  (Siedlungsentwicklung, Industrie, Landwirtschaft, Tourismus)
  - mit steigendem Wasserverbrauch steigt auch der Abwasseranfall!
  - Versorgungssicherheit
  - Wasserschutz
aber auch Verhinderung von Fehlentwicklungen wie

- Tendenz: Jedem Nutzer sein Brunnen
- Richtig jedoch wäre verstärkte Schonung der Grund-/Trinkwasserressourcen beim Einsatz in der Landwirtschaft, Industrie und kommunalem Gebrauch

Wie verträgt sich “Nachhaltigkeit” mit freiem Wettbewerb?

Kann ein solcher bei der Wasserressourcennutzung überhaupt funktionieren?

Wassermanagement/Informationssysteme (z.B. WIS Kärnten)

Lösung “heißer Eisen” wie

Entschädigungsleistungen
Förderungsmaßnahmen zum Nutzen des “Wassers”
Eigentum am Wasser

Sicherstellung des Zugriffes auf das sozial und ökonomisch notwendige Wasser

Österreichische Wasserrecht erfüllt in hohem Maße alle Anforderungen, muß nur entsprechend angewendet werden! (v.a. Vorsorgeprinzip, Vorbeugungsprinzip und Verursacherprinzip)

Implementierung der Wasserfragen in andere Politikbereiche
Results of Workshop 2

Results obtained within the workshop

Matching the english, french and german meaning, “Sustainable” is being understood as:

- Protection and management of resources in view of future needs
- Balance of natural resource and demand at regional / catchment scales

Within considered physiographical areas (at various scales) and national and economic boundaries; there is a need to keep in sight an approach to solutions of transnational problems.

*The EC-framework “River Basin Management” could be a guideline for this.*

Some examples:

- Definition of sound priorities in water uses
- Transparency of decision making
- Long term monitoring of water quantity and quality of the resources (n.b. climatic-/ecosystem change)
- Integrated resource management (in space and in time)
- No “waste” of resources

**Concession Policy**

- Incentives
- Multiple use of water
- Optimization of systems
- Reduction of losses
  
  Legal, Financial & Technical aspects
This implies:

Better understanding of natural hydrological regimes and sound management of reservoirs especially:

- Residence Time Evaluation
- Evaluate/investigate layering and Groundwater Mixing Systems
- Improved recharge evaluation
- Conflict analysis etc.

There must be a place for innovative solutions and new technologies for better use of water, so avoiding rigid regulations (legislation...)

- Need for observation of long term changes (climatic, hydrochemical etc.)

- Need for education and training public awareness
  - e.g. the nature of the water resource,
  - development of tourism and leisure activities
  - which respect the environment

*Wider integration in main environmental projects (e.g. Agenda 21)*
Additional remarks to the results of the Workshop 2

G. SUETTE

“Sustainable” should be understood as defined during the workshop as

“Protection and management of resources in view of future needs”

“Balance of natural resource and demand at regional /catchment scale”

In general, there should be included, that in the sense of “sustainable” measures, touching the ground water, should be given in greater parts a reversible situation after finishing such measures.

For a further definition it seems to be necessary to define the field of conflicts in the following way:

**CONFLICTS**

<table>
<thead>
<tr>
<th>QUALITY</th>
<th>QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste deposits</td>
<td>Drinking water use</td>
</tr>
<tr>
<td>Agriculture - fertilizers, pestizides, manuring</td>
<td>Industrial use</td>
</tr>
<tr>
<td>Waste water</td>
<td>Agricultural use</td>
</tr>
<tr>
<td>Surface water of roads, industrial plants, and so on</td>
<td>Touristic use (snow plants f.i.)</td>
</tr>
<tr>
<td>Interaction between ground water and surface water</td>
<td>Hydro electric use</td>
</tr>
<tr>
<td>Loss of soil – erosion in common</td>
<td>Interaction between ground water and surface water</td>
</tr>
<tr>
<td>Recharge of used water (except of geothermal use)</td>
<td>Geothermic use of deep groundwater</td>
</tr>
<tr>
<td></td>
<td>Balneologic use of deep groundwater</td>
</tr>
<tr>
<td></td>
<td>Drainage by tunnels</td>
</tr>
<tr>
<td></td>
<td>Long distance transport out of catchment areas</td>
</tr>
</tbody>
</table>

All these points should be included into the discussion of the term “sustainable” to reduce conflict situations.

---

25 Office of the Provincial Government of Styria, AUSTRIA
The examples, given in the paper “results and statements of WS 2”, should be explained in the following way:

| Definition of sound priorities in water uses | ➢ Human use (drinking water quality standard)  
[71x697]  
➢ Animal use  
➢ Use for industrial, agricultural and touristic demands |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transparency of decision making</td>
<td>Each decision is to be set up in clear, transparent way and should include a monitoring system</td>
</tr>
<tr>
<td>Long term monitoring of water quantity and quality of the resources</td>
<td>This monitoring should be orientated at the “Wassergüteerhebungsverordnung” for special parameters</td>
</tr>
<tr>
<td>Integrated resource management (in space and time)</td>
<td>It is important, to practice an integrated resource management because of an long term overview of changes in the way of using ground- and surface water</td>
</tr>
<tr>
<td>No “waste” of resources</td>
<td>This point should be orientated f.i. at the Austrian Act of Water or comparable Acts of other member states of the EU</td>
</tr>
</tbody>
</table>

Additional to the Paper of Villach and to the remarks, given above, it seems necessary, that each use of water – ranging over small isolated uses for single households – has to be accomanied by exact investigations, which include as well conventional investigations, monitoring activities as modellings.
Workshop 3²⁶

„Research Priorities in Running Water Ecology

Concept:

A. PETER* AND S. SCHMUTZ**

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The solution of water related conflicts in alpine environments require a better understanding of ecological functions and processes. The workshop aims to evaluate research priorities in running water ecology. Realisation of these priorities will provide the basis to effectively improve the ecological status of alpine rivers.

Human influences on running water ecosystems have been an accelerating factor in modifying the aquatic habitat and the land-water interactions. The modifications of important processes caused completely different structures (habitat/biological community) and functions in the aquatic systems. The workshop will focus on human impacts in alpine streams and rivers. Today only few alpine rivers (5-20 %) can be regarded as near natural or natural ecosystems. In order to prevent flooding of surrounding land, many rivers and streams were channelized. Intensive hydropower use causing river damming, water abstraction and hydropeaking is very common in all alpine regions. Obvious effects of such human influences were habitat fragmentation, loss of connectivity, and substantial habitat degradation and loss.

Various presentations of the preceding conference and their discussion will give an overview of the present status of alpine rivers. The most severe human impacts on these ecosystems will be identified and compared with current scientific knowledge to highlight research deficits. Analysis of international research activities and possibilities, like the RTD 5th Framework Programme, will demonstrate the ability and the

²⁶ Conveners: Armin Peter, Stefan Schmutz, Participants: Irene Gabriel, Hans-Christian Hofmann, Mathias Jungwirth, Piotr Parasiewicz, Christian Smoliner
shortcoming of current and forthcoming programmes to cover research deficits.

The output of this workshop will be the identification of existing shortcomings and the development of new research priorities. Strategies to encourage future tasks will be discussed.

Preliminary programme

1. Introduction: Definition of workshop targets
2. State of the ecological situation of alpine running waters
4. Current research activities and possibilities: 5th R&D Framework
5. Current international research activities: Report of the 27th SIL-Congress Dublin

6. Research deficits and demands in various areas
   - channelisation, land use
   - effects of hydropower use: hydropeaking, minimum flow, flow regime, floodplain
   - interruption of habitat connectivity, habitat fragmentation
   - chemical and ecotoxicological contamination, endocrine disrupters,
   - non native fish species, fishery management
   - global change: water temperature
   - restoration and mitigation

7. Implementation activities - Memorandum

8. Workshop summary
Results of Workshop 3

World-wide running waters belong to the most intensively used and altered ecosystems. Highly populated alpine regions of Central Europe are characterised by serve human impacts (only 5% to 20% of alpine rivers are left in nature-like stage).

According to scientific concepts running waters are understood as four dimensional systems of complex physical, chemical and biological processes.

An integrated management approach is essential for preservation and sustainable use of running water systems. Ecological issues are crucial components of such an approach and therefore progressively included in recent research strategy papers of European Union. Nevertheless, further extension and specification are required. Using available documents published by the Community (Council Decision on 5 FW, Taskforce Water, Network WatER, Water Framework Directive) and information on the most adverse effects of human impact following priority areas could be defined to be included in the EU research programmes:

**Documents and Materials**

- 5\textsuperscript{th} Framework
- Task Force Water
- WatER: Wetland and Aquatic Ecosystem Research plan
- SIL: International limnological society
- Water Framework Directive
Biological Research Priorities

1. Function of aquatic ecosystems (5-FW)
   - Characterisation of reference conditions (water quality) and natural variability, river classification/typology
   - Significance of spatial and temporal connectivity and interrelation between various organisation levels of aquatic ecosystems (up- and downscaling)
   - Ecotone (land/water interfaces)

2. Integrated river basin management (5-FW) (conservation, restoration, mitigation)
   - Biological response to hydrological alterations e.g. hydropoeaking, water abstraction (minimum flow), flushing, flood protection, reservoirs, sediment transport change, land use change
   - Biological response to habitat deterioration, fragmentation and disruption of river continuum and connectivity e.g. channelisation, dykes and damming, land use change
   - Biological response to land use e.g. urbanisation, agriculture, forestry, landscape planning
   - Water pollution e.g. endocrine disrupters, ecotoxicology
   - Climate change e.g. temperature problems, hydrological and sediment transport problems

3. Methodologies and management tools (5-FW)
   - Multifunctional use of aquatic ecosystems: concepts, assessment, ...
   - Development, harmonisation, and standardisation of methods for biological water quality assessment and monitoring (transboundary and multilateral actions)
   - New technologies for water quality (sensu WFD) surveillance (remote sensing etc.)
   - Predictive modelling (back- and forecasting)

The proposed biological research topics should be closely linked to socio-economic and biodiversity programmes within 5-FW program.
Workshop 4

Integrative Catchment and Disaster Management

Concepts

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1. Changes within the natural habitat and its consequences for disasters
   - climate change and hydrological characteristics
   - anthropogenic influences such as urbanisation, tourism, changed land use patterns on torrential floods, slope stability and forest situation
   - development of protection forest functions landslide and erosion activities and hydrological patterns

2. Sustainable land use and forest management as fundamental requirements for stability in alpine regions
   - research on the influence of vegetation on soil erosion, flood control and slope failure
   - analysis of the functions of protection forests and methods of melioration
   - implementation of criteria and indicators for sustainable forest management for promote natural regeneration of protection forests, erosion control and peak flow reduction

Conveners: Albert Göttle, Hanspeter Nachtnebel, Participants: Panagiotis Balabanis, Aniello Amendola, Dieter Gutknecht, Harald Kittl, Norbert Sereinig, Hans Zojer
3. Improvement of data bases in alpine catchments for sustainable management and disaster prevention
   - hydrology in small alpine catchments
   - geological and geomorphological survey, mapping of avalanches, landslides and erosion
   - land uses and morphological development
   - qualified digital terrain models and aerial photograph analysis for hazard analysis and flood control concepts
   - glacier and permafrost line changes and their results on the natural regime

4. Risks handling, uncertainties and preventive planning
   - security standards, estimation of destruction potential, relative security and residual risks
   - principles for assessment, limits of disaster prevention by forestry and technical measures
   - requirements for calculation of mud flow, debris and woody debris flow
   - harmonisation of torrent classification, hazard zone mapping and security efforts
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Integrative catchment management has to harmonise economic, social and ecological objectives within the basin. Appropriate management strategies have to consider not only water resources but also the utilisation of other resources like land management. In the alpine region the emphasis should be on the consideration of forestry, developments of settlements and adapted land use in general.

Many alpine basins, even when a smaller scale is considered, are international basins requiring transboundary water management. Typical examples are the Inn flowing from Switzerland, to Austria, Germany and back to Austria; the Rhone river with the two riparian countries Switzerland and France, and the Upper Rhine which drains parts of Switzerland, Liechtenstein and Austria; the Upper river Drau with subbasins in Italy, Austria and Slovenia, and several other examples could be listed.

With respect to appropriate disaster management a classification of disasters seems to be appropriate which could refer to natural disasters and man made caused events. Natural disasters may include land slides, glacier outburst, avalanches and extreme floods. Human activities like inappropriate land use may enhance the frequency or the magnitude of such events. Further, the failure probability and the subsequent risk of direct human interventions has to be considered. Disaster Management has to include monitoring systems, predictive models, emergency and warning plans as well as adequate institutional settings.
The following key points should be addressed in the workshop:

What is the appropriate framework for integrative management?
Which information is required?
Which measures (structural, non-structural) are useful for integrated management?
How has the decision making process to be designed?
Is the institutional setting appropriate?
How to implement integrative management?
How to manage transboundary problems?
Which variables (indicators) should be monitored with respect to disasters?
Which types of disasters are of major importance?
What is the role of human activities in the occurrence of disasters?
Which preventive measures are efficient and implementable?
To what extent are disasters predictable?
How reliable can be disaster impacts predicted?
Who is responsible for the development of emergency plans?
Which institutional settings are necessary for warning and actions?
General Remarks

Integrative catchment management has to harmonise economic, social and ecological objectives within the basin. Appropriate management strategies have to consider not only water resources but also the utilisation of other resources like land management. In the alpine region the emphasis should be on the consideration of forestry, developments of settlements and adapted land use in general.

With respect to appropriate disaster management a classification of disaster seems to be appropriate which could refer to natural disasters and man made caused events. Natural disasters may include land slides, rock fall, mud flow, glacier outburst, avalanches, extreme floods, droughts and forest fires. Human activities like inappropriate land use may enhance the frequency, the magnitude and the consequence of such events. Further, the failure probability and the subsequent risk of direct human interventions has to be considered. Disaster Management has to include monitoring systems, predictive models, emergency and warning plans as well as adequate institutional settings.

Research Deficits

The following research tasks have been identified by the members of the working group:

- Requirements for integrated management
- Assessment of risk and disaster management
- Impacts of land and resources use
- Requirements for the implementation of integrated management
- Long term external impacts
Requirements for integrated management

Starting from the general objectives for integrated catchment management which refer to the harmonisation of economic, ecological goals the specific aspects and problems of a region have to be explicitly considered to ensure the long-term stability of a region. Also, the cultural heritage and the social values of the community in the region should be included.

Research needs and information deficits are seen in:

- Understanding of the processes in the natural system including observation of catchment changes, data collection and analysis,
- Scenarios should be based on appropriate land use, especially sustainable forest management and adapted agricultural practices
- To improve the decision making process methods for generation of alternative development scenarios, techniques of decision making and the involvement of the public, handling of transboundary interactions and interests, improvement of the legal basis require further research.

Assessment of risk and disaster management

Classification of natural and human induced impacts. The main natural disasters in the alpine region are in land slides, avalanches, extrem floods and in mud and debris flow. In the Southern mountainous regions of Europe the problem related to droughts and forest fires should be considered too. Often, such disasters occur under influence of cascade effects.

To provide a rational basis for the management the following points should be addressed in research

- Documentation of disasters
- Geological and morphological survey
- Elaboration of a European wide soil map
- Development and implementation of monitorin systems including
- Predictive tools.
To ensure the proper assessment of risk

- Guidelinings for environmental impact assessment in the Alpine region
- Methodologies for risk assessment and subsequent risk handling
- Principles for risk sharing within the society (upstream, downstream relations, local and regional scale, equity considerations)
- The role of insurance policies

have to be elaborated and investigated.

With respect to management the following points are seen as important above all:

- Establishment of a basin wide institutional network
- Elaboration and implementation of emergency plans
- Raising the awareness of the public of the main threats
- Provision and amelioration of logistics, resources and recommendations for the case of emergency
- Early warning systems for all types of disasters.

**Impacts of land and resources use**

Human induced impacts are mainly due to inappropriate land and resources use. Research deficits are seen in

- The links among land use and the hydrological cycle, especially among forest management, development of settlements, hydropower utilisation, tourism, migration problems
- Deficits exist also in a continuous documentation of land use
- A historical analysis of the development in some typical regions to improve the understanding of the processes within the catchment
- A clear definition of the reliability related to technical structures like dams, dikes, reservoirs and an assessment of the consequences of any failure is required for sound decision making
Identification of criteria for compatible resources use

Requirements for the implementation of integrated management

To enhance the implementation of integrative management some institutional aspects are addressed:

- Improved data base easily accessible by all involved institutions
- Institutional networking and a co-operative framework has to be facilitated
- Guidelines how to involve the public and NGOs
- Techniques and guidelines for transboundary collaboration
- Pilot projects should be carried out to study the deficits in integrative management at the local and regional level.

Longterm external impacts

The impacts of climate change on

- The natural habitat,
- Especially on the hydrological patterns
- Erosion processes
- Glaciers and permafrost line
- The development of protection forest functions

needs further long term monitoring and research.
Workshop 528.

Environmental Monitoring and Assessment

Concepts

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Agenda of Workshop and Topics of Discussion

Introductions of participants

Overview of „technical“ problem objectives:

• Quantity & Quality of Surface and Ground Waters

• The Water-Soil-Subsurface Ecosystem

Societal Setting: Hydrological aspects of the European Union 5th Framework Programme


Eurowaternet: identification of gaps that hinder the answers to burning scientific questions

Scientific and Technical Issues (see below for a partial selection)

Communications: How to make politicians aware of problems/deficiencies/needs and convince them of the need for action.

28 Conveners: Antonis Koussis, Franz Nobilis,
Participants: Klaus Fröhlich, Klaus Granica, Martin Kralik, Gernot Paulus,
Ivan Pilas, Pertti Seuna
Structure of the Workshop

Discussions in two parts: Water Quantity and Water Quality

Joint Assessment of gaps and overlaps

Formulation of common positions for the presentation to the general audience on 30/9/98

Suggestions for Scientific and Technical Issues (not listed in order of priority)

Trans-boundary issues, e.g. International Rivers (Rhine, Danube, Tajo etc.)

Administration of Water Rights

The unsaturated Zone (e.g., hydrocarbon leaks and spills)

Data needs for model verification/calibration

Pollution from agricultural activities: streams, lakes/reservoirs (eutrophication), ground water

Old Landfills

Sediments („first flush“ phenomenon – Combined Sewers Overflow)

Use of Remote Sensing and Telematics
• DATA COLLECTION FOR:
  ✓ WATER RESOURCES ENGINEERING PURPOSES
  ✓ HYDROLOGIC SCIENCE

• HYDROLOGICAL DATA ARE NEEDED TO:
  ✓ MEASURE FLUXES & RESERVOIRS IN THE HYDROLOGIC CYCLE
  ✓ MONITOR HYDROLOGIC CHANGE (or LACK OF IT)

• HYDROLOGIC PROCESSES OPERATE OVER A WIDE RANGE OF SCALES
  ✓ TEMPORAL: FROM SECONDS TO MILLENNIA
  ✓ SPATIAL: FROM THE MOLECULE TO THE GLOBAL

• DETECTION OF HYDROLOGIC CHANGE REQUIRES:
  ✓ A COMMITTED, INTERNATIONAL, LONG-TERM EFFORT, and
  ✓ THAT THE DATA MEET RIGOROUS STANDARDS OF ACCURACY

• SYNERGISM
  BETWEEN MODELS AND DATA IS NECESSARY TO DESIGN EFFECTIVE DATA COLLECTION EFFORTS TO ANSWER SCIENTIFIC AND APPLICATIONS-RELATED QUESTIONS.

• LONG-TERM MONITORING AND THE USE OF PALEOHYDROLOGIC RECORDS ARE FUNDAMENTAL TO UNDERSTANDING THE ROLE OF EXTREME EVENTS (FLOODS & DROUGHTS) IN HYDROLOGIC SYSTEMS
• USEFUL HYDROLOGIC DATA REPRESENTING PROCESSES AT THE GLOBAL SCALE ARE SPARSE; MOST HYDROLOGIC DATA HAVE BEEN COLLECTED WITH LOCAL-SCALE, OR AT BEST NATIONAL-SCALE QUESTIONS IN MIND

• A FUNDAMENTAL OBSTACLE TO PROGRESS IN USING MOST HYDROLOGIC DATA IS POOR KNOWLEDGE OF HOW TO INTERPOLATE BETWEEN MEASUREMENT POINTS

• SOME IMPORTANT HYDROLOGIC EVENTS INVOLVE RARE, SHORT-LIVED AND CATASTROPHERIC PROCESSES (VOLCANIC ERUPTIONS, INTENSE FOREST FIRES, INDUSTRIAL ACCIDENTS), WITH MAJOR INFLUENCES ON FLOODING AND SEDIMENTATION, ON RUNOFF AND EROSION, AND ON CHEMICAL POLLUTION

THE PROBABILITY IS LOW THAT AN INSTRUMENTAL NETWORK WILL BE IN PLACE TO RECORD SUCH EVENTS ADEQUATELY. THEREFORE, THE ABILITY TO ORGANISE RAPIDLY CO-ORDINATED CAMPAINS FOR DATA COLLECTION IN THE FIELD IS ESSENTIAL
FRANZ NOBILIS

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e-mail: franz.nobilis@bmlf.gv.at

1. The following points may be of interest to discuss:

- Hydrological aspects of the 5ht EU Framework Programme (a general lecture will be given by Mr. Balabanis) with respect to the title of the workshop
- Gaps in the Eurowaternet to answer burning scientific questions
- Guidelines to define scientific projects of commercial interest
- Cooperation in the field of existing bilateral and multilateral treaties
- Ways to convince politicians

2. The workshop could be structured in two parts:

- Discussing in two parts water quantity and water quality
- Bringing together the experts after and looking for overlapping or gaps
- Finalizing the ideas for presentation

3. The following background material, which I will bring to Villach, may be of interest:


ETCIW: Briefing Note for Contributors to EEA`S Budapest Workshop, 29 and 30 October 1998


RESULTS OF WORKSHOP 5

Introduction

The participants of Workshop 5 decided to focus on Data Collection for the purpose of “Environmental Monitoring & Assessment”. It is recognised, however, that a more complete view includes sampling analysis, data handling and dissemination of information as well as use of data in assessments, via, e.g., statistical analysis and modelling.

We wish to highlight the sensitivity and importance of Alpine and Alpine-like environments for the hydrologic cycle as well as the great difficulties in obtaining adequate and representative data in such environments that are characterised by intense relief, with high spatial variability, strong seasonal changes and difficult access. We envision that application of presently available cutting edge technologies (e.g., remote sensing, telemetry) and development of new equipment will help the resolution of some of these issues.

Data collection is an activity prescribed by law in the member states of the European Union. It is a part of the statute of the multitude of governmental organisation involved in water resources activities. The tasks that pertain to data collection encompass, at least, quantity and quality of surface and ground water. We stress that biochemical quantities/indicators are also included.

For lack of time, the group did not consider the entire soil-water-vegetation system. However, the interconnections between the individual elements of the system are considered to be well-established. Neither did the group endeavor to include the atmospheric component of the problem, which couples the atmospheric and hydrologic cycles and relates to the Global Climate Change issues.

Water Data are collected

a) to provide water information in order to meet national and international requirements and/or obligations originating from agreements/treaties,

b) as prescribed by statute, in which case they serve the purpose of water resources management, i.e., a mission-oriented, applied activity with well-defined goals, and

c) for the advancement of hydrologic science, i.e., the development of new knowledge, especially including inter-disciplinary collaboration.
Hydrologic data are needed in order to:

a) measure fluxes and reservoirs in the hydrologic cycle, and

b) monitor hydrologic cycle (or lack of it).

Included in the hydrologic cycle are mass transport processes, with their associated variables (concentrations and mass fluxes). The data collection and evaluation efforts are directed towards securing the knowledge that is a pre-requisite for improved management. The relevant information concerns:

- the dynamics of hydrologic systems
- the interaction between water and other environmental/ecological systems, and
- the human impact on quantity and quality of water resources

The main difficulties of the data collection task lie in the fact that hydrologic processes operate over an enormous range of temporal and spatial scales.
**DEFICITS, DEMANDS** | **SOLUTION**
---|---
Classification of water quality network | e.g., EUROWATERNET
Classification of water quantity network | proposal by Nordic countries (IHP)
Analytical quality assessment, control & assurance of entire monitoring procedure | 
Lack of coordination between model use and data collection | 
Regionalization | 
Forecasting systems including early warning systems | Quantity: RIPARIUS, WMO; Quality: AWS (Danube)
Operational hydrological reference basins | WMO
Isotopes as a routine hydrological parameter | GNIP, e.g., monitoring for rivers and groundwater
Dealing with fluxes in addition to point information | Coordination
Remote sensing, e.g., radar, optical methods | CEO, COST
Data | EEA (similar to GRDC, Koblenz)
- access to existing data | 
- accuracy | 
- comparability | 
- real time | 
Standardization | CEN (norms)
- methods and procedures | 
- terminology | 
- assessment of data uncertainty | 
Snow measurements | remote sensing
Precipitation rate and deposition of atmospheric constituents/pollutants at high altitude at alpine regions | Establishment of a network for collecting snow packs
Unsaturated zone | 
- lysimeter monitoring | 
Sediments | 
How to make decision-makers aware of problems? | 
- cost/benefit assessment and studies even as simple as possible | 
How to make the public aware of problems? | 
- public relation work at different levels (public education) |
4. WORKSHOP CONCLUSIONS

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It is obvious that there exists a wide field of research deficits in the Alpine environment in order to minimize water related conflicts of interests. For the time being it was easy to elaborate a catalogue in this respect. The main discussion has taken place on the scientific and administrative demands how to reach proper solutions for the benefit of the population and how to develop a sustainable growth not endangering the environment. Thus, the discussions to achieve proper solutions where shifted some to the background, but nevertheless some results look promising.

Definitions

Alpine regions: It was stated that this term includes mountainous regions in general and is not restricted to the Alps.

Sustainability: The overall discussion of this term is still not finished, since its meaning by direct translation into different languages is still not clear. In this connection it is wise to refer to Brundtland’s call for sustainable development and creating the slogan „from the restrained growth to the sustainable development“. The actual requirements should be fulfilled without diminishing the chances for a beneficial development of future generations.

Integrative management: The objectives must be defined in a way to allow resources management at large catchment scale. One of the main focus refers to interactions between surface and groundwater. The harmonization of economic, ecological and social aspects with respect to the utilization of natural resources is highly recommended.
Objectives

Longterm stability of a region: The integrative management should allow to keep the natural and the man made system of a region in an equilibrium. This includes also a proper landuse management with special regard to Alpine forestry, development of settlements, touristic activities and the construction of mountain roads.

Understanding of water related processes in the natural system: For the protection of groundwater it is essential to know the underground pathways: hydrological processes during the infiltration from the surface, rock-water interactions effecting the groundwater mineralization groundwater mass transport and dissolved solid transport, chemical and biological reactions.

Socio-economic aspects: They include interactions between the economic development and the social integration, relation between Alpine and surrounding regions, communication between enterprises and environmental protection groups.

Alpine reference basins

Scientific challenge: A sustainable utilization of water resources is limited naturally by its nonuniform distribution according to climatological and geological conditions. The pressure of population development on the one hand and the global environmental problems on the other hand require a more integrated view in utilizing water resources. Their sustainability is undoubtly incorporated into changes of water balance based on the climatic evolution. Climate models ought to quantify hydrological effects in order to ensure a long term and efficient water resources management. Such objectives are orientated to small catchment areas as well as to large and crossbordering river basins. Therefore the whole actual system of natural and man influenced groundwater recharge has to be observed and controlled in order to guarantee a high standard of sustainability. Since water utilization is focused on different objectives, it is essential to develop structures for a multifunctional and sensitive use of water resources.

Catchment management: The main focus is directed to the effects of rural developments as well as of the urbanization in valley fields on the regional runoff regime and the consequences of transboundary river management by regionalization of the results. The large river basins and their sub-catchments extended from the high located Alpine regions to
the lowlands around (e.g. river basins of Rhone, Rhine, Danube and Po) are of special interest.

**Risk analysis**: To overcome inundations and droughts the elaboration of emergency plans is essential including the forecasting, planning and management of water supply as well as the recognition of boundaries for water utilization. Tremendous floods in the lowlands sometimes originate from heavy rainfall events and snow melts in high Alpine regions. They require the necessity to retain water in high located regions by daming up rivers and streams or by subsurface storage of water recharged artificially depending on the geological conditions.

**Transboundary management**: In Alpine regions the aquifers are developed generally in fractured and fissured rocks. A concept of crossborder water resources management needs the delimitation of catchment areas, the calculation of groundwater recharge and storage and the determination of protection zones for drinking water in accordance with the water law.

**External impacts**: They need a longterm monitoring since they are depending on climate change.

**Interdisciplinary links:**

**Landuse**: The infiltration zone (unsaturated zone) as the link between surface and groundwater has been omitted considerably in the past. It acts also as a key for the recognition of causal relationships on the vertical groundwater recharge as well as on groundwater pollution originating from the land surface. Thus, conclusions to the landuse practices can be drawn.

**Rivers**: In this respect a biological response can be given with special emphasis to minimum runoff by abstraction, to reservoir flushing, to flood protection and to man made changes of the sediment transport.

**Climate change**: Climate changes with evidences for recent increase of temperature in Europe is well proved, on the other hand the scientific efforts to quantify their effects on the water balance must be still strengthened. Such considerations require certainly an interdiscipline approach of natural sciences with history and socio-economics.
Contamination: Since industrial agglomerates are very rare, water contamination in Alpine areas in the most cases are deriving from weak waste water treatments. Appropriate and cost effective waste water treatment systems as well as the implementation of sewage sludge utilization programmes have to be developed.

Observation and monitoring

Structural systems: Although the earth’s crust looks stable, in a geological time scale it is full of dynamics, sometimes expressed by earthquakes and volcanic eruptions. The observation of geological movements, of the evolution of landscape and of the development of soils is necessary.

Mobile systems: While the geological structure forms the aquifer matrix, the underground water represents its flexible part. Its natural flow is depending on the atmospheric conditions (climate), the vegetation on the surface and the permeability of the rock formations. A considerable research need is given for the development of appropriate sensors, which are capable for continuous recording in an outdoor environment. The offer of measuring and testing methods should be extended enabling a better forecasting, planning, managing and remediating of water supply systems.

Time and scale

Distribution of fluxes: For the monitoring of contaminants in surface and underground water ist is not sufficient to operate with concentrations only, but to introduce, wherever possible, water masses in order to be able to calculate flux balances.
Consequences

As administrative results of the workshop following recommendations can be stated:

- to develop guidelines for the sustainable use of water in Alpine regions due to the location of natural resources and the quality demands of the individual users;
- to establish and to upgrade institutional networks for the improvement of communication processes;
- to accelerate decision making processes on a fundamental scientific basis;
- to integrate the society in environmental risk assessments;
- to organize the public information in a sensitive way;
- to consider cost-benefit assessments also under environmental conditions
5. POSTER PRESENTATION

The Application of the CROFHIS Data Base in Groundwater Data Analysis of the Pokupsko Basin, north-west Croatia

BORIS VRBEK & IVAN PILAS

SUMMARY

Groundwater is one of the most important ecological factors in the lowland forests of Croatia. Forest ecosystems have, in the last few decades, been exposed to a very strong anthropogenic influence, hydromeliorative proceedings, which cause changes in the water regime and leads to forest weakening.

Permanent monitoring of the groundwater regime is established in the field to collect information about changes in it. This information is accumulated and then analysed at the Forest Research Institute Jastrebarsko with the aid of the CROFHIS programme (Croatian Forest Hydopedological Information System).

This data presents the basis for further research into the relationship between groundwater, soil, phytocenosis and forest conditions. The given results are then applied in silviculture and forest management as well as in the influence of hydromeliorative works on forest ecosystems. This paper contains the results of a four year monitoring (1994-1997) on fifteen piezometric stations, four wells and four canals in the lowland forests of the Pokupsko Basin in the north-west region of Croatia.

The regime of groundwater is analysed for specific types of soil of this region. These results are then compared to measurements of groundwater taken from 1980-1993.

Key words: lowland forests, CROFHIS, groundwater, piezometers, soil.

29 Forest research Institute, Jastrebarsko, Croatia
Groundwater Quality in Austria
2000 Monitoring Wells are Reporting

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D. GRUBER¹ and W. VOGEL¹

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BACKGROUND

Groundwater is one of the most important drinking water resources in 
Europe as well as in other parts of the world. The existing European 
regulations set high priorities to protection of the ground water for 
drinking water supply (EEC). In Austria more than 99% of drinking water 
is taken from groundwater. About 50% of this comes from carbonate 
and crystalline rocks (karst and fractured aquifers) of differing ages the 
most important of which are located in more remote Alpine areas where 
tourism is significant. Due to their particular structure karst aquifers are 
more vulnerable to pollution than groundwater in porous aquifers. The 
remaining 50% is abstracted from quaternary and tertiary sediments 
(porous media). These sedimentary basins are densely populated areas 
where the land use is generally agricultural and industrial. The 
complexity of the properties and the dynamics of the various aquifers in 
Austria means that conditions vary markedly over small areas. This 
means that it is essential to run a dense monitoring network in order to 
ensure that pollution problems are detected early so that appropriate 
prevention measures can be taken.
THE AUSTRIAN WATER QUALITY MONITORING SYSTEM (AWQMS)

New legislation and administrative procedures forming the basis for the AWQMS for ground water and surface waters were adopted in 1990 with the primary goals being to achieve a representative knowledge of the overall ground water quality in order to establish background impacts, trends and the compliance with legislation (Ordinance on Water Quality Monitoring (“Wassergüte-Erhebungsverordnung“)). Both federal and regional authorities as well as many private laboratories are involved in implementing the monitoring system itself. This is shown in Fig. 1.

The network for monitoring water quality consists of about 2000 sampling sites selected by experts on the basis of hydrological, geological and geochemical knowledge (Fig. 2). 1782 of the monitoring points are situated in the 150 porous groundwater bodies of large basins and glacial overdeepened alpine valleys. In these regions a sampling density of about 10-15 km² per sampling site is attained. A combination of specific monitoring points, domestic wells, industrial abstraction points and water supply boreholes are used as sampling sites in order to obtain a more or less regular pattern of monitoring sites. The remaining 237
monitoring points are situated in the Alpine karstic and fractured rocks with a density of between 160-360 km² per sampling site.

Since 1991 all wells and springs have, for the most part, been sampled four times a year with between 50 and 100 physical and chemical parameters being analysed for each sample. The analysis of the samples is conducted by private laboratories with special attention being paid to standardisation and analytical quality assurance.

The laboratories are selected through competitive call for tenders with inspections of the laboratories being conducted before the awarding of a contract as well as regularly thereafter by an independent central laboratory. The total annual costs for sampling and analytical work are about 2.9 Mio ECU. Easy access to the data for every parameter and sampling site can be had through the internet (http://www.ubavie.gv.at) and biennial expert reports (WWK/UBA 1993, 1995, 1997).

**GROUNDWATER IN POROUS MEDIA**

The quality of groundwater in porous media is threatened by both diffuse and point sources of pollution. The most significant pollutants in Austria are nitrate and pesticides but chlorinated hydrocarbons are also important. Whereas nitrate and pesticides are mainly from diffuse, agricultural sources, chlorinated hydrocarbons are from point sources such as industries and contaminated sites. The most significant results of the groundwater quality monitoring programme and assessment for these substances are given below.

The Ordinance on Groundwater Limit Values (Federal Legal Gazette No 502/91 and 213/97) establishes threshold values for groundwaters. These are set in line with the precautionary principle and, as a general rule are less than or at most equal to drinking water supply standards. If these threshold values are exceeded over a period of 2 years or more at least 25% of sampling sites within a groundwater body remediation measures have to be introduced by the regional authority.
Fig. 2: Groundwater monitoring in Austria (1998). Porous aquifers and spring sampling sites
Nitrate

Results for nitrate in groundwater are given in Tab. 1 for each of the nine Austrian provinces as well as for Austria as a whole. Detailed analyses of time series from 1992 to 1995 showed that, taking Austria as a whole, there has been no significant change in concentrations during this period (details in BRANDSTETTER & SCHWAIGER, 1997; PHILIPPITSCH; 1997).

Tab. 1: Nitrate in Austrian groundwaters in porous media (period 1991 to 1995)

<table>
<thead>
<tr>
<th>Classes \ Provinces</th>
<th>Bgld</th>
<th>Ktn</th>
<th>NÖ</th>
<th>OÖ</th>
<th>Sbg</th>
<th>Stmk</th>
<th>T</th>
<th>Vbg</th>
<th>W</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>% &lt; 10 mg/l</td>
<td>34.2</td>
<td>39.8</td>
<td>26.8</td>
<td>22.6</td>
<td>65.5</td>
<td>30.6</td>
<td>64.9</td>
<td>83.9</td>
<td>13.9</td>
<td>36.4</td>
</tr>
<tr>
<td>% &gt;10 – 30 mg/l</td>
<td>20.9</td>
<td>37.9</td>
<td>31.8</td>
<td>39.0</td>
<td>26.7</td>
<td>31.5</td>
<td>34.4</td>
<td>15.9</td>
<td>18.2</td>
<td>31.6</td>
</tr>
<tr>
<td>% &gt;30 – 45 mg/l</td>
<td>9.4</td>
<td>11.4</td>
<td>14.1</td>
<td>23.5</td>
<td>6.6</td>
<td>15.1</td>
<td>0.6</td>
<td>0.1</td>
<td>12.0</td>
<td>12.8</td>
</tr>
<tr>
<td>% &gt;45 – 50 mg/l</td>
<td>2.9</td>
<td>2.0</td>
<td>3.7</td>
<td>4.9</td>
<td>0.7</td>
<td>4.8</td>
<td>0.1</td>
<td>0.0</td>
<td>3.8</td>
<td>3.2</td>
</tr>
<tr>
<td>% &gt; 50 mg/l</td>
<td>32.5</td>
<td>8.9</td>
<td>23.6</td>
<td>10.1</td>
<td>0.5</td>
<td>18.0</td>
<td>0.0</td>
<td>0.1</td>
<td>52.2</td>
<td>16.0</td>
</tr>
<tr>
<td>Total No of analyses</td>
<td>1402</td>
<td>2123</td>
<td>4034</td>
<td>2774</td>
<td>832</td>
<td>3052</td>
<td>1489</td>
<td>768</td>
<td>577</td>
<td>17051</td>
</tr>
</tbody>
</table>

Bgld: Burgenland; Ktn: Carinthia (Kärnten); NÖ: Lower Austria (Niederösterreich); OÖ: Upper Austria (Oberösterreich); Sbg: Salzburg; Stmk: Styria (Steiermark); T: Tirol; Vbg: Vorarlberg; W: Vienna; A: Groundwater in porous media in Austria.

Atrazine:

Although the use of Atrazine in Austria was banned in 1995, of the 47 pesticides for which samples were regularly analysed it main decomposition product desethylatrazine remain the most frequently present (GRATH et al. 1997), with the concentration exceeding in many cases the level of 0.1 µg/l set as a threshold value in the Ordinance on Groundwater (see above) and drinking water standards. However, new evaluations show a clear falling trend (annual report 1997).

The percentage of groundwater samples with concentrations of atrazine and desethylatrazine above 0.1 µg/l is given in Table 2 for each of the nine Austrian provinces as well as for Austria as a whole (1.1.1992 – 30.6.1995).
Tab. 2: The presence of atrazine and desethylatrazine in Austrian groundwaters in porous media (1.1.1992 – 30.6.1995)

<table>
<thead>
<tr>
<th></th>
<th>Bgld</th>
<th>Ktn</th>
<th>NÖ</th>
<th>OÖ</th>
<th>Sbg</th>
<th>Stmk</th>
<th>T</th>
<th>Vbg</th>
<th>W</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N° of samples</td>
<td>1351</td>
<td>2116</td>
<td>3941</td>
<td>2774</td>
<td>832</td>
<td>3033</td>
<td>1486</td>
<td>767</td>
<td>480</td>
<td>16780</td>
</tr>
<tr>
<td>% Atrazine &gt; 0.1 µg/l</td>
<td>27</td>
<td>11</td>
<td>22</td>
<td>39</td>
<td>6</td>
<td>35</td>
<td>5</td>
<td>3</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>% Desethylatrazine &gt; 0.1 µg/l</td>
<td>28</td>
<td>26</td>
<td>27</td>
<td>52</td>
<td>11</td>
<td>46</td>
<td>11</td>
<td>5</td>
<td>45</td>
<td>32</td>
</tr>
</tbody>
</table>

Bgld: Burgenland; Ktn: Carinthia (Kärnten); NÖ: Lower Austria (Niederösterreich); OÖ: Upper Austria (Oberösterreich); Sbg: Salzburg; Stmk: Styria (Steiermark); T: Tirol; Vbg: Vorarlberg; W: Vienna; A: Groundwater in porous media in Austria.

**VOLATILE CHLORINATED HYDROCARBONS IN POROUS GROUNDWATER**

The occurrence and frequency of chlorinated hydrocarbons in groundwater in porous media can be found in GRATH and BONANI (1997). The specific characteristics of the transport of various chlorinated hydrocarbons and the possibilities of detection of these substances in this monitoring network are discussed in WWK/UBA (1993).

In the following table the four most frequently found hydrocarbons are presented. Tetrachlorethene (called Perchlorethylene or “Per”) is the most frequent substance reported in groundwater, followed by Trichloretene, 1,1,1-Trichlorethane and Chloroform. Other substances such as Tribrommethane, Bromdichlormethane, Dibromchlormethane, Dichlormethane, 1,2-Dichlorethane, Tetrachlormethane and 1,1-Dichlorethene) are detected at few monitoring sites only.
Table 3: Selected chlorinated hydrocarbons in groundwaters in porous media (7/93- 6/95)

<table>
<thead>
<tr>
<th>Substances</th>
<th>&lt; MDL</th>
<th>&gt; MDL</th>
<th>&gt; 6 µg/l</th>
<th>&gt; 10 µg/l</th>
<th>Total No. of monit. Sites</th>
<th>Maximum µg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td></td>
</tr>
<tr>
<td>Trichlorethene</td>
<td>1508</td>
<td>91.4</td>
<td>134</td>
<td>8.12</td>
<td>4</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1533</td>
<td>92.5</td>
<td>117</td>
<td>7.1</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloroform</td>
<td>1539</td>
<td>92.9</td>
<td>118</td>
<td>7.1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

MDL: Minimum detection limit

**GROUNDWATER IN KARST AND FRACTURED AQUIFERS**

The water quality in more than 90% of the samples from karst and fractured crystalline rock aquifers is excellent. Where „elevated concentrations“ are found, they are in reality only slightly above natural median concentrations. The situation is quite different from groundwaters in porous media, where the concentrations of contaminants are usually much higher. It is also important to note, that the concentrations in karst spring waters should not be summarised as mean values because the degree of dilution varies greatly depending on precipitation, snow melt etc.

**POLLUTION SOURCES OF SPRING WATERS**

Temporary microbiological contaminations of karst water is considered to be a problem for drinking water supply (KRALIK 1999). These are caused by intensive tourism, cattle or game and occur in spring waters mainly after heavy rainfalls. In many cases this potential for contaminations necessitates specific treatment of karst water for drinking water supply.
Tab. 4: Mean and other statistical data of selected groundwater contaminants in karst and fractured crystalline aquifers. (1995-1997)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Median</th>
<th>Min*</th>
<th>Max</th>
<th>10%</th>
<th>25%</th>
<th>75%</th>
<th>90%</th>
<th>&gt;MDL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₃-Karst (mg/l)</td>
<td>3.8</td>
<td>2.7</td>
<td>&lt;1.0</td>
<td>40.7</td>
<td>1.18</td>
<td>1.7</td>
<td>4.5</td>
<td>7.1</td>
<td>1919</td>
</tr>
<tr>
<td>NO₃-Fract. (mg/l)</td>
<td>4.8</td>
<td>1.68</td>
<td>&lt;1.0</td>
<td>127</td>
<td>&lt;1.0</td>
<td>1.2</td>
<td>3.5</td>
<td>10.5</td>
<td>594</td>
</tr>
<tr>
<td>As-Karst (mg/l)</td>
<td>0.0004</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.049</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>1253</td>
</tr>
<tr>
<td>As-Fract. (mg/l)</td>
<td>0.0009</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.022</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>396</td>
</tr>
<tr>
<td>Pb-Karst (mg/l)</td>
<td>0.0004</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.020</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>1220</td>
</tr>
<tr>
<td>Pb-Fract. (mg/l)</td>
<td>0.0011</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.225</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>384</td>
</tr>
</tbody>
</table>

>MDL: Percentage of measured samples is above the given “Minimum Detection Limit” (Federal Legal Gazette: BGBL 1991a); * Min: Minimum (the official MDL are given here, although some laboratories have even lower detection limits); 10%: 10% percentile e.g. 10% of the measured values are below the 10. Percentile, 90% above etc; Fract.: fractured crystalline rock aquifers.

Ninety percent of the waters sampled showed a natural composition far below any limit values. During the investigation period maximum admissible drinking water values were exceeded in just 9% of the samples. However, 24% of the 237 sampled springs exceeded the limit values temporarily. These concentrations are caused by the natural leaching of sulphate and chlorides of gypsum, salt formations. Human contamination e.g. phosphate and pesticides (atrazine) is also likely to play a role.

Many of the other analysed contaminants exceed the detection limit (>MDL; Tables 4 and 5) in just few percent of the analysed samples. The maximum admissible drinking water concentration for nitrate is exceeded in one sampling point. Admissible concentration levels of atrazine and desethylatrazine were exceeded on 7 occasions in the hills and basin of SE Styria where intensive agriculture is practised. Traces of chlorinated hydrocarbons below limit values occur in springs which have tourism and small-scale industrial use in their drainage areas (Table 5).

Although the concentration of pollutants in remote alpine areas is low their apportionment is possible through factor analysis. Agricultural sources are characterised by elevated levels of NO₃, atrazine or
desethylatrazine. while sewage are indicated by elevated PO₄-B concentrations and atmospheric pollution may be indicated by NH₄-NO₂ concentrations. Elevated PO₄-B concentrations are most frequent around sedimentary basins in Carinthia, Salzburg and Vorarlberg, where traces of chlorinated hydrocarbons occur in some places.

Tab. 5: Mean and other statistical data of AOX and selected chlorinated hydrocarbons and in karst and fractured crystalline aquifers. (1995-1997)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Median</th>
<th>Min*</th>
<th>Max</th>
<th>10%</th>
<th>25%</th>
<th>75%</th>
<th>90%</th>
<th>n</th>
<th>&gt;MDL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOX-Karst (µg/l)</td>
<td>1.42</td>
<td>&lt;1.5</td>
<td>&lt;2</td>
<td>77.6</td>
<td>&lt;1.5</td>
<td>1.5</td>
<td>2.5</td>
<td>4.1</td>
<td>819</td>
<td>35.7</td>
</tr>
<tr>
<td>AOX-Fract. (µg/l)</td>
<td>0.67</td>
<td>&lt;1.5</td>
<td>&lt;2</td>
<td>8.1</td>
<td>&lt;1.5</td>
<td>&lt;1.5</td>
<td>&lt;1.5</td>
<td>2.9</td>
<td>280</td>
<td>20.4</td>
</tr>
<tr>
<td>111-Trichlorethane</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>0.29</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>1098</td>
<td>0.3</td>
</tr>
<tr>
<td>111-Trichlorethane</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>0.6</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>323</td>
<td>0.9</td>
</tr>
<tr>
<td>Tetrachloreh.(Per)</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>0.8</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>1098</td>
<td>1.2</td>
</tr>
<tr>
<td>Tetrachloreh.(Per)</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>0.2</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>323</td>
<td>0.3</td>
</tr>
<tr>
<td>Tetrachlormethan</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>1.4</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>1098</td>
<td>0.1</td>
</tr>
<tr>
<td>Tetrachlormethan</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>0.3</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>323</td>
<td>0.3</td>
</tr>
<tr>
<td>Trichlorethen (Tri)</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>0.6</td>
<td>&lt;0.1</td>
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Heavy metals concentrations are generally below or just above the minimum detection levels (MDL), but only exceed the limit values in a few springs. They are generally attributed to natural mineralisations in the Fischbacher Alpen (As), the Steirisches Hügelland (Pb, Zn, As, Hg) and the Northern Calcareous Alps (Pb, Zn, Hg). Concentrations just above the minimum detection levels (MDL) of lead in some springs in Vorarlberg have yet to be explained.

**LITERATURE**


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6. EXCURSION TO DOBRATSCH

Karstwater storage and protection of Dobratsch massif
(Carinthia)

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Abstract

The Villacher Alp massif consists predominantly of Triassic carbonate rocks. Intensive tectonics favours karstification. Compared to other karst regions there exists a contrast between the water scarce plateau and the big karst springs at the foothills of the massif. The main outlets are located at the N, NE and E, named Nötschbach, Union and Thomas spring and the cold water and thermal district of Warmbad Villach respectively. The latter is subjected to an own differentiated drainage system. The mean discharge of Thomas and Union spring – used for water supply of the Villach region – ranges together almost 400 l/s, the same amount can be reached by the thermal outlets, but only as a seasonal maximum. The Nötschbach spring exceeds 1 m³/s at flood conditions.

Hydrochemical and isotopical investigations can gather important indications of recharge areas and subsurface storage of karst water. By means of Ca/Mg ratio ist could clearly determined whether the springs are recharged in dolomite or limestone formations, provided that the lithology of the strata is known. Tritium measurements are highly suitable for the calculation of the mean residence time of subsurface waters. Applying the exponential model the mean water age of Nötschbach, Union and Thomas spring ranges between 3 and 6 years. The thermal water of Warmbad Villach must be considered as a mixed water of different components: The hot water part probably is free of tritium, the cold water component on the other hand is stored subsurface only for a short time, similar to the cold water springs in the vicinity around.

Long term measurements of $^{18}$O can also be applied for the detection of the mean residence time of karst water. The large seasonal
fluctuations at several springs (Römerquelle, Ressmannquelle) indicate a very limited underground storage of water. The main hydrogeological use of $^{18}$O data is reflected to the vertical distribution of recharge areas taking into account the altitude effect of the stable isotope. Thus, the Nötschbach spring recharges from the uppermost part of the massif, the catchment area of the thermal springs on the other hand is located at the lower plateaus of the Eastern Villacher Alpe.

Furthermore the delimitation of recharge areas was defined by a combined tracing experiment. It has been proved that summer and winter tourism in a special area without control affects to a high extent the quality of drinking water at Union and Thomas spring. However, the different tracers have been injected in dolines, which represent preferential subsurface flow paths. Therefore it was not surprising that the tracers reappear very quickly, within a few days only, at several springs.

A hydrograph separation was carried out at Union spring using the natural ions Na$^+$ and Mg$^{++}$. It results that even at high outflow conditions during a melting period in spring 1988 30-50 % of the total discharge originate from base flow (longer stored component), which suggests a reasonable storage capacity of spring water. All hydrogeological investigations show in a synoptic way a clearly indicated risk potential for the drinking water around the karst massif of Villacher Alpe. Because of the knowledge of subsurface flow path different priorities for the karst water protection can be worked out.

**Environmental assessment related to water resources**

**KARST WATER RECHARGE PROCESSES**
- Geology and geomorphological evolution
- Climatology
- Infiltration measurements and modeling

**KARST WATER DISCHARGE AND STORAGE DYNAMICS**
- Base flow recession
- Isotope hydrograph separation
- Solute transport modeling
- Water balance modeling
REPRESENTATIVE LANDUSE AND ENVIRONMENTAL RISK MONITORING

- Terrestrial landuse monitoring
- Remote sensing application
- Risk assessment from human impact

DATA MANAGEMENT AND GIS INTEGRATION

- Data acquisition and elaboration
- Conceptual risk analysis
- GIS risk modeling

LONG TERM STRATEGIES OF SUSTAINABILITY

- Conflict assessment in land and water use
- Sustainability assessment
- Optimization of resources utilization

REGIONALIZATION OF RESULTS

- Boundary conditions
- Optional approaches
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Water related conflicts of interests in the Alpine environment

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