The use of groundwater crustacean communities as indicators for aquifers quality in the semi-arid region of north-central Chile

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BACKGROUND

Chile has large extensions of arid and semi-arid regions throughout the whole country, where the intensive demands and use of groundwater resources especially for irrigations and mining activities increased dramatically over the last decades. The aquifer depletions due to water abstraction for irrigation and nutrient loads exert major alterations of water quality, changes in groundwater recharge and of the natural renewal rate. All these factors diminish the aquifer value for users and contribute to the degradation of groundwater as environment and habitat for fauna. The intensive use of groundwater resources in Chile brought to significant social and economic benefits, however their inadequate management resulted in negative environmental, legal and socioeconomic consequences.

Fig. 1 The location of Coquimbo region (a) and irrigation field (b) in the Choapa Valley (Chile)

STUDY AREA

The study has been performed in two glacial aquifers from Coquimbo region in the Choapa watershed, 250 km north of Santiago de Chile (Fig. 1a). Choapa basin extends between 31°10'–32°15'S and 70°16'–71°33'W and cover an area of ca. 7,630 km^2.

The basin is bounded on the east by Chile's Andean Mountains reaching 6900 m above sea level and to the west by the Pacific Ocean. The climate of the region varies from coastal steppe at the coast to cold temperate at the headwater. The annual rainfall is scarce in Illapel (the main city) is 170 mm (region annual rainfall is 100-240 mm/yr and decreasing) whereas the annual total evapo-transpiration reaches 1,500 mm.

The average temperature of the area is around 15°C. A major control for precipitation events, in addition to the altitude, is the 5–7-a return period of the El Niño-Southern Oscillation (ENSO) phenomenon, which includes extremely rainy years (El Niño) as well as extremely dry ones (La Niña), the latter associated with highly recurrent drought events (Nuñez et al., 2011). The floodplain of Choapa is dominated by agriculture (fruits tress, vineyards) (Fig. 1b) .

OBJECTIVES

We here aim to provide a first assessment of environmental alterations of groundwater ecosystems from agricultural watersheds in northern Chile by specifically evaluating the effects of nitrogen load on groundwater communities and identifying the ecosystem service alterations due to agricultural activities.

APPROACH

- WATER
  - *Major ions*: total carbon, inorganic carbon, phosphor, nitrogen, F-, Cl-, NO2-, NO3-, PO43-, SO42, Na+, NH4+, K+, Mg2+ Ca2+
  - Isotopes O, H
  - Heavy metals
  - Pesticides, herbicides & fertilisers
- BIOTA
  - Biodiversity
  - Spatial distribution
  - Ecological structure
- USE
  - Land use / cover
  - Piezometers use: driniking vs. irrigation

METHODOLOGY

Two sampling campaigns were performed in October and November 2017. A total of 15 boreholes have been sampled for water and groundwater fauna. The location of the boreholes is shown in Fig. 2 and a brief description and of water properties in Table 1. The biological sampling (Fig. 3) was performed following the standardized protocols cf. the general methodology to assess the groundwater biodiversity established in PASCALIS (Protocols for the assessment and conservation of aquatic life in the subsurface, Malard et al., 2004).

Table 1 The characteristics of the sampled boreholes from Choapa Valley, Chile

SITE NAME	COORDINATES E	COORDINATES S	Elevation (m a.s.l.)	AQUIFER	Phreatic level	EC (µs/cm)	pH	Temp (°C)	DO (mg/L in %)
Batuco	348007	6463920	1164	CHOAPA ALTO	1.88	301	7.22	19.87	59
Cuncumén	346215	6468701	1018	CHOAPA ALTO	9.48	569	6.84	16.925	40.7
Tranquilla	340966	6470035	927	CHOAPA ALTO	6.53	527	6.89	18.53	62.8
Llimpo	325256	6474724	667	CHOAPA ALTO	1.56	553.5	6.89	18.04	17
Panguesillo	324099	6475756	660	CHOAPA ALTO	4.3	495.5	6.94	17.51	25.35
Santa Rosa 2	3148713	7055902	578	CHOAPA ALTO	0.2	448	6.96	18.44	33.2
El Tambo	309048	6481712	387	CHOAPA ALTO	5.86	547.5	6.84	14.29	37.25
Chuchiñí	304930	6484651	392	CHOAPA ALTO	1.36	786	6.85	19.1	26.2
Pozo Sta Rosa	317309	6478770	546	CHOAPA ALTO	6	464	6.82	17.09	10.1
La Colonia 2	3135436	7104894	441	ILLAPEL	1.9	1273	7.24	16.81	0
Boldo	3146517	7059366	524	CHOAPA ALTO	2.98	640	6.87	16.7	20.4
Carcamo3	3135699	7103538	493	ILLAPEL	2	671	6.91	15.87	18.2
Carcamo 4	3135483	7103712	540	ILLAPEL	0.5	536	7.4	15.3	22.7
La Colonia 1	3153786	7039461	470	ILLAPEL	2.22	662	6.71	17.35	16.5
Illapel	3138385	7110474	387	ILLAPEL	0.35	1110	6.86	17.32	16.7

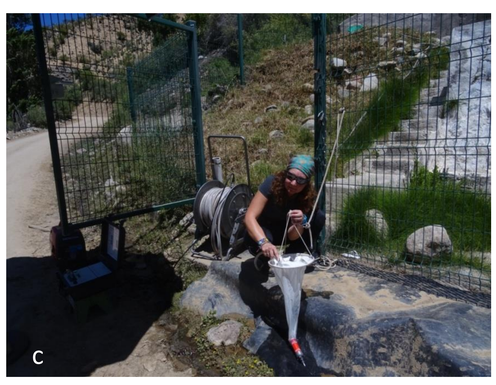

Fig. 4 Groundwater fauna sampling in the aquifers of the Choapa Valley, Chile (a-d)

RESULTS

The hydrogological characteristics of the two aquifers are illustrated in Table 2. Due to low regional precipitations (100-240 mm/year) the aquifers are primarily recharged by snowmelt from the Andean chain and by surface runoff.

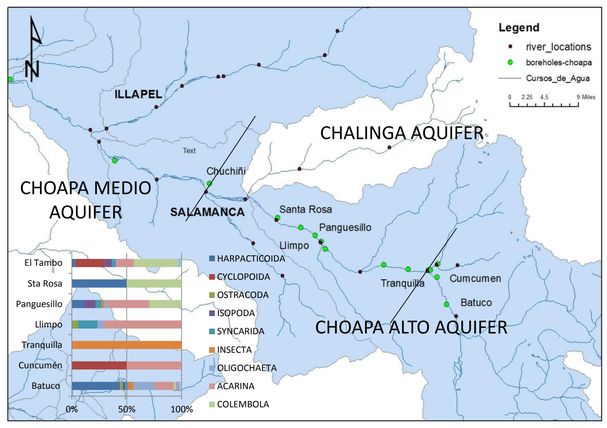

Fig. 2 Boreholes location in the Choapa Valley, Chile (a), abundance of groundwater invertebrates (b).

Table 2 Characteristics of the investigated aquifers in the Choapa Valley, Chile

	Characteristics
Region	Choapa Alto and Medio (Coquimbo Region) between 31°10´S and 32°15´S; extension of 8100 km^2
Geology	unconsolidated deposits filled with fluvial sediments (gravel, sand, silt) + glacial and fluvioglacial sedimentation from moraines
Age	Quaternary
Aquifers	There are 4 aquifers in the area of study but they are hydraulically connected and is considered a unique aquifer
Recharge	Snowmelt, precipitations, high surface / groundwater exchanges with the Choapa River
Permeability	Low
Transmisivity	400 y 3000 m^2/day
Vulnerability	High
Water quality	High EC, high load of SO4, As, Cu and Mn surpassing the standard limits for its use as drinking water (cf. N.Ch409/2005) and for rrigation (cf. N.Ch 1333)

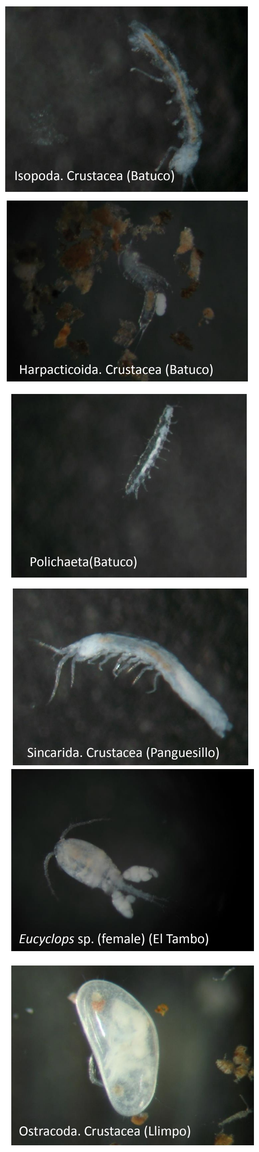

Fig. 4 Groundwater invertebrates sampled in the aquifers of the Choapa Valley, Chile

A total of 13 taxonomic groups including crustaceans (Bathynella, Amphipoda, Cyclopoida, Harpacticoida, Ostracoda and Isopoda) has been found in the sampled borehole (Figs. 2b, 4). The taxonomic richness and the presence of stygobites have been related more to groundwater level stability than to chemical water parameters indicating that over-exploitation of borehole is the primary factor influencing the groundwater fauna likely due to the negative impact on habitat suitability.

The evolution of groundwater crustacean in different biogeographic regions worldwide is reflected in a particular biodiversity underground. In these regards, Chile, by its geographic position and specific past and present climate (currently with extremely reduced precipitations) might host one of the most unique groundwater species worldwide that evolved underground in complete isolation. In the specific region of Coquimbo, the groundwater is currently under high treats due to overexploitation and contamination, and this specific fauna might disappear even before being discovered. Groundwater biota assessment is essential in understanding the impact produced by agriculture activities on groundwater as a resource and as ecosystem, a nexus that becomes more and more widely recognized.

References

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