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1 **First characterization of physicochemical and biological variables of the salt**
2 **wetland dayat Morsli in Oran (Algeria)**

3

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17

18 **Abstract**

19 Known to be on the outskirts of the city of Oran, 'dayat Morsli' is an endoreic wetland
20 in western Algeria, and has suffered from many years of anthropogenic pollution
21 (industrial and waste water). Dayat Morsli pool had never been characterized before,
22 and the aim of this work is to understand the hydrological functions and the dynamic
23 of this closed wetland, by monitoring biological, physical and chemical parameters for
24 one year (2017). Water samples were collected monthly all around the lake.
25 Measured parameters consisted of water level, pH, salinity, temperature, organic
26 matter and phytoplankton abundance, in addition to the concentration of organic
27 pollutants, nitrates and phosphates. The concentration of five heavy metals -
28 cadmium, lead, iron, zinc and copper - was also determined. The results show that

1

29 dayat Morsli is characterized as a salty to moderately salty wetland. The pH and
30 salinity vary with the temperature and water level throughout the months. The
31 phytoplankton cell concentration decreases with decreasing depth and increasing
32 salinity. In parallel, during the second period of the year (June - December), organic
33 matter accumulates and sediments out, while it decomposes during the first period.
34 Moreover, nitrates and phosphates, essential elements for phytoplanktonic
35 development, are found at concentrations above the standards with respective
36 concentrations of 150 mg/L (NO₃) and 6 mg/L (P), maybe causing the eutrophication
37 of the wetland. We have shown that the average concentrations of Cd and Pb in
38 water were higher than the allowed values. This study provides a better
39 understanding of the functioning of dayat Morsli over one year, but also of the
40 physicochemical and biological interactions in this small closed ecosystem.
41 Moreover, these results could be used as a basis for the rehabilitation project of this
42 wetland.

43

44 1. Introduction

45 Wetlands are the most productive and diverse ecosystems on the planet ([Sieben et](#)
46 [al., 2018](#)). There are distinct and extremely diverse ecosystems in form, size,
47 formation and geographical location ([Teixeira et al., 2014](#)). They include natural and
48 artificial marshes, filled by fresh, brackish or salt water. Various categories exist:
49 marine and coastal wetlands, coral reefs, estuarine waters and salt marshes, inland
50 wetlands with rivers, streams, freshwater lakes, salt lakes, brackish lakes and
51 artificial wetlands such as agricultural ponds, salt marshes and dams ([Ennabili and](#)
52 [Ater, 1996](#); [Hammer, 1986](#)). They can also be described in terms of salinity, and
53 subdivided into fresh (1 - 3 g/L of salt), hyposaline or brackish (3 - 20 g/L),
54 mesosaline (20 - 50 g/L) and saline and hypersaline (> 50 g/L) water ([Hammer, 1986](#);
55 [Semeniuk and Semeniuk, 1997](#)). Wetlands represent inundated ecosystems, where
56 complex ecological processes occur due to interactions between water, vegetation
57 and soil ([Beaumais et al., 2008](#)). Vegetation in wetlands is an essential component of
58 this ecosystem and plays an important role in the ecological functions ([Ennabili and](#)
59 [Ater, 1996](#); [Bouldjedri et al., 2011](#)). They are also a reservoir of biodiversity and a
60 paradise for waterbirds ([Merken et al., 2015](#); [Al-Obaid et al., 2017](#); [Andreotti et al.,](#)

61 2018; Cherkaoui et al., 2018). During the last centuries, these environments have
62 been subjected to an important degradation due to anthropization effects. Indeed, in
63 wetlands, human actions are the main factors of such a degradation (Shengjie et al.,
64 2017).

65 In this article, we study a wetland in Northwestern Algeria. Dayat Morsli, or ‘small
66 lake’ of Oran, is the name given to this natural endoreic wetland. The term “dayat”
67 refers to a closed depression in the shape of a basin, more or less vast (a few meters
68 to several hundred meters in diameter). Dayats are located between the
69 Mediterranean and Saharan regions. According to Köppen's classification, northern
70 Algeria has a semi-arid climate characterized by a long dry season and a wet season
71 with low rainfall. From the climatic data over the last 25 years
72 (<https://www.infoclimat.fr/observations-meteo/temps-reel/oran-es-senia/60490.html>
73 (last access: June 22 2019)), it was found that 2017 was an exceptional year, with
74 the lowest rainfalls (247 mm) and the highest average temperatures (19.1 °C).
75 Moreover, over the last 25 years, Es-Senia precipitation was higher than the year
76 2017, with a mean of 386 mm and mean annual temperatures of 17.8°C which is
77 1.3°C below those registered in 2017 (<https://fr.climate-data.org/> (last access: July 19
78 2019)). The dayats are periodically flooded; rainwater and runoff water flow and
79 concentrate in these environments. The accumulation of water in the dayat allows the
80 formation of a relatively deep soil (more than one meter deep) and functions as
81 evaporation pans (Kaabeche, 2012). The proportions of dissolved ions are affected
82 by the natural geochemical composition of aquifer rocks. In fact, the major ions in salt
83 water are the same as those in freshwater, Na⁺, K⁺, Ca⁺, Mg⁺, Cl⁻, SO₄²⁻ and CO₃²⁻,
84 but the ionic proportions are different. In salt lakes, Na⁺ and Cl⁻ are the dominant
85 ions, while HCO₃⁻ is the dominant ion in freshwater lakes (Kuşcu et al., 2017).

86 As mentioned above, dayat Morsli is a natural closed depression (35°40' N; 0°36' W),
87 with a kidney circle shape, a flat bottom and a 150 ha area, with average dimensions
88 of 1.78 km length and 1.09 km width (Fig. 1). It is part of the Oran plateau, which is
89 located in the Chelif basin extension. The plateau is bounded to the north by the
90 Mediterranean Sea, to the west by the mountain side of Mount Murjadjou, and to the
91 south by a salt flat-bottomed depression called ‘The Big Sebkhah’ of Oran (Fig. 2)
92 (Benziane, 2013). The topographic depression of dayat Morsli is filled with soft
93 sedimentation: alluvium and loam. The open water is about 2 m depth in the centre

94 with diverging flow in the south. Dayat Morsli is located in the municipality of Es-
95 Senia which has nearly 97 500 citizens. Salt lake is delimited in the east by unused
96 agricultural lands, and by the urban agglomeration of Oran in the north, comprising
97 1.5 million inhabitants. It is surrounded by an industrial area and a railway in the west
98 and the south. This area includes about ten industries, a foundry, wallpaper and
99 plastic processing plants, as well as an agro-food plant and raw material storage
100 sites. The depression has suffered from many years of industrial pollution and urban
101 waste. Since 2010, dayat Morsli has been a biosphere reserve protected by the city's
102 environmental protection authorities, and the municipality has decided to stop all
103 rejections by court order. Now, dayat Morsli is only fed by rainwater and road
104 drainage water (channels which can be partially closed). Since 2017, a project for the
105 rehabilitation and transformation around the site has been underway, to make it a
106 place of entertainment, resorts, and leisure site for the citizens. Before the
107 rehabilitation project, the area was contaminated by industrial and urban wastes, and
108 about 360 families lived close to the wetland in precarious dwellings. In February
109 2016, the dismantling of the city slums was carried out in this area. Dayat Morsli has
110 never been explored before and the aim of this work is to understand the functioning
111 and dynamic of this wetland by studying some physicochemical and biological
112 parameters all along a year.

113

114 2. Materials and methods

115

116 2.1. Sampling procedure

117 Monthly, in 2017, at each sampling point ([Fig. 1 C](#)), water samples (triplicates) were
118 collected using three polyethylene bottles of 1 litre each one, which was rinsed with
119 water to be sampled, filled, stored in an icebox and then transported to the
120 laboratory. Sampling was performed on seven points at the border around the study
121 site. The middle area was not accessible due to the deep mud and could not be
122 explored.

123 According to the seasons, the collection was done in the water surface, from the
124 surface to 6 cm depth in the wet season, when the wetland is filled, and 2 cm to the

125 upper surface of the sediment in the hot season, when the wetland is dry, avoiding as
126 much as possible stirring the water and resuspending sediments.

127 For this purpose, a monthly monitoring of the physicochemical parameters was
128 carried out throughout 2017: pH, temperature, water levels, salinity, organic matter
129 concentration, phosphates and nitrates concentrations and the concentrations of five
130 heavy metals: cadmium (Cd), lead (Pb), zinc (Zn), iron (Fe) and copper (Cu) were
131 measured. A monthly microphytoplankton and microzooplankton count was also
132 carried out to quantify the living part of the dayat.

133

134 2.2. Analysis of physical, chemical, and biological parameters

135 *In situ*, the level of water with a measure tape, the temperature and the pH with digital
136 EXTECH ® 500 (Extech instruments, Boston, USA) were measured three times in
137 each of the seven points. In the laboratory, salinity, nitrate and phosphate, organic
138 matter and heavy metals were measured in triplicate on water sampled.

139 The salinity was determined from chloride concentration, using chloride precipitation
140 titration (Rodier et al., 2009). 10 mL water samples were titrated with a silver solution
141 (0.2 N), in the presence of potassium chromate indicators (5%). The end point was
142 indicated by the persistence of the orange silver chromate colour. The total nitrate
143 and phosphate concentrations were measured according to the instructions of test
144 kits HANNA-HI 93728-0 nitrate reagent and HANNA-HI 93717 (A, B) phosphate HR
145 reagent (HANNA Instruments Inc, Rhode Island, USA). The results were expressed
146 in mg/L. The organic matter weight was determined after filtration of 50 mL of water
147 samples, using Whatman GFC filters and drying at 70 °C during two hours to remove
148 the residual water, after heating at 450 °C during four hours to burn organic matter.
149 The results were expressed in g OM/L.

150 For measuring heavy metals, 20 mL of water samples were filtered under vacuum
151 through Millipore filters of 0.22 µm (Filtropur S, SARSTEDT, Numbrecht, Germany),
152 to eliminate suspended solids. Then, 0.5 mL of concentrated nitric acid was added for
153 preservation (Yazidi et al., 2017). Then, the samples were analysed for cadmuim,
154 lead, zinc, iron and copper metals, using an atomic absorption spectrometer (AAS),
155 (Analytikjenna, novAA® 350, Germany). The results were expressed in ppm.

156 Changes in a wetland volume during the annual cycle were calculated from the
157 monthly water levels measured at the sampling points and from the Landsat 8
158 satellite imagery on March 1, 2017 (when water levels reach the highest point) and
159 September 15, 2017 (when water levels are at the lowest peak). From the image of
160 March 1, 2017, where the total surface of the wetland is visible and from the image of
161 September 15, 2017, where it is possible to distinguish the water levels according to
162 the colour levels, a manual segmentation was performed using the QGIS version 3.4
163 software to determine three depth ranges of the wetland (deep zones, mid-depth
164 zones and shallow areas). Variations in the volume of the wetland during the annual
165 cycle were then determined from the water depths measured monthly on the
166 sampling points (shallow areas) and on the basis of the maximum known depth of 2
167 m of the wetland (deep zones). The mid-depth zones corresponded to the difference
168 between the two ranges.

169 Each month, three replicates per site were biologically analyzed. The living cells were
170 prefixed instantly after collection by mixing 10 mL of water samples with 40 μ L of
171 Lugol. During cell counting, the microphytoplankton was determined according to the
172 morphological criteria described by Prescott (1970). The microphytoplankton and
173 microzooplankton cell abundances were carried out under the optic microscope,
174 using a counting cell. Cell counts were performed on 10 cells of a Malassez cell slide.

175

176 2.3. Statistical Analysis

177 Statistical analyses were performed with the software R_{3.4.1} (R., 2005). All
178 measurements were made in triplicates, except for cell counting and organic matter
179 quantification. The repeatability of the values obtained was verified by a simple linear
180 model. The result showed that all measurements were highly repeatable ($F_{83-168} >$
181 120 and $p < 10^{-3}$). The means of the three measurements were used thereafter.

182 To analyse the difference between the sites and the temporal variation, a Principal
183 Component Analysis (PCA) was created with the FactoMineR package. The global
184 PCA showed that there was no difference between the sites; we decided to make
185 mixed linear models with the site named as random factor with the *nlme* package and
186 the *lme* function. For chemical characteristics, the fixed variables were temperature,

187 water level and months. For biological characteristics, the variables were the same
188 with chemistry added.

189 Before analyzing the data, a correlation between the variables was checked ([Sup.
190 data S1](#)). For the correlated variables (chemical data) a PCA was performed to
191 output uncorrelated variables that summed correlated variables. Indeed, nine
192 correlated variables (salinity, pH, Cd, Fe, Zn, Cu, Pb, P and NO₃) were replaced by
193 two uncorrelated variables ChiPC1 and ChiPC2. Two dimensions were chosen. The
194 choice was supported by 5 (out of 9; 55.56%) methods (Optimal Coordinates, Parallel
195 Analysis, Eigenvalues (Kaiser Criterion), Velicer MAP, VSS Complexity 1) according
196 to the psycho package method ([Makowski, 2018](#)). The both uncorrelated variables
197 did not represent a chemical measure but a global variation supported by the nine
198 correlated variables.

199

200 3. Results

201 3.1. Seasonal variation of parameters

202 Concerning the physicochemical and biological parameters, PCA showed that there
203 was no difference between the seven sites, but a difference is observed between the
204 months of the year ([Fig. 3](#)). Two periods were clearly identified, on the one hand, the
205 period 1 including January to May, and on the other hand, the period 2 from June to
206 December. All corresponding physicochemical analysis graphs are presented in
207 [Figures 4, 5 and 6](#).

208 The period 1, from January to May, was marked by a high water level 32 ± 12 cm, a
209 high pH 9 ± 0.5 and a large number of living cells in the water $249 \times 10^3 \pm 208 \times 10^3$
210 cells/mL, with the occurrence of a bloom between March and April including several
211 species such as a dominant microalgae *Dunaliella salina*. Two macroalgae species
212 *Ulva* sp. and *Mougeotia gracilis* were generally detected on the studied sites. In
213 parallel, a low salinity 30 ± 1.7 mg/L and a variable temperature, as well as low
214 nitrate 90 ± 7 mg/L, phosphate 4.4 ± 0.3 mg/L and stable organic matter 2.3 ± 0.3 g/L
215 concentrations ([Fig. 4 and 5](#)) were registered in this period 1. In contrast, the period
216 2, from June to December, a decrease of the water level 9.8 ± 3.2 cm, pH 8.3 ± 0.6
217 and of the numbers of cells at $1.8 \times 10^3 \pm 0.6 \times 10^3$ cells/mL was observed. On the

218 contrary, the remaining parameters showed higher values than previously:
219 temperature and salinity with a maximum of 40 °C and 56 mg/L in August. Nitrate
220 and phosphate show a maximum between July and October before decline (Fig. 5).
221 The organic matter varies from a maximum of 10 ± 0.01 g/L in September to a
222 minimum of 0.06 ± 0.01 g/L in October (Fig. 4). Concerning the variations in the
223 volume of the wetland, it was evolving with the same seasonal trends and had a
224 volume of 1.95×10^6 m³ in March to 1.47×10^6 m³ in September, which represented
225 important variations in the year.

226 During the first three months of the year, in the water, a decrease is observed in
227 cadmium 0.04 ± 0.02 ppm (Fig. 6a), in copper 0.09 ± 0.01 ppm (Fig. 6b) and in zinc
228 0.07 ± 0.03 ppm (Fig. 6c). For iron and lead, the months of April and May were
229 relatively linked as shown by the green circle in Figure 3, and an increase in iron 2.1
230 ± 0.1 ppm (Fig. 6d) and lead 1.3 ± 0.2 ppm (Fig. 6e) is observed. During the period 2,
231 the concentration of heavy metals remained relatively stable, with concentrations of
232 0.71 ± 0.05 ppm for Cd, 0.2 ± 0.03 ppm for Cu, 0.04 ± 0.02 ppm for Zn, 0.2 ± 0.07
233 ppm for Fe and 1.1 ± 0.2 ppm for Pb (Fig. 6).

234

235 3.2. Physicochemical and Biological Parameters Relationship and Influence

236 The result of the chemical principal correlation analysis showed that: 1) Dimension 1,
237 named ChiPC1, was positively correlated with salinity, nitrate, phosphate, and lead
238 and negatively with pH and zinc (Sup.data S2). This dimension could be assimilated
239 to 'salinity' since chemical elements evolved in different ways over time with salinity
240 being the most influential element in the remaining chemical variables 2)
241 Dimension 2, named ChiPC2, was positively correlated with iron and lead, and
242 negatively correlated with copper (Sup. data S2). ChiPC2 corresponded to the iron
243 concentration and the absence of copper.

244 To provide a better understanding of the evolution of physicochemical parameters,
245 mixed linear models were performed in order to see the influence of temperature and
246 water height over the months on the chemical parameters, named ChiPC1 and
247 ChiPC2. The results showed that ChiPC1 varied according to months ($F_{11,84} = 3\ 929$,
248 $p < 10^{-3}$, Fig.7 a) and temperature ($F_{1,84} = 7$, $p = 0.001$). When the temperature

249 increased the salinity increased (Fig.7 b), whereas ChiPC2 only depended on months
250 ($F_{11,84} = 3\ 929$, $p < 10^{-3}$, Fig. 8).

251 Abundance of cells varied with the months, it was higher and more variable during
252 the first months than the rest of the year ($F_{11,84} = 111$, $p < 10^{-3}$) (Fig. 9 a). However,
253 cell number also varied with increasing water height ($F_{1,84} = 5$, $p = 0.02$) and to some
254 extent with a decreasing salinity ($F_{1,84} = 3$, $p = 0.08$) (Fig. 9 b). During the last 6
255 months the concentration of organic matter has varied enormously with two peaks at
256 7.5 g/L in September and December ($F_{11,84} = 156$, $p < 10^{-3}$). The increase in heavy
257 metals (ChipC2) and temperature influenced the concentration of the organic matter
258 ($F_{1,84} = 15$, $p < 10^{-3}$, Fig. 10 a; $F_{1,84} = 13$, $p < 10^{-3}$, Fig. 10 b).

259

260 4. Discussion

261 In ecosystems and particularly in wetlands, it is important to know the
262 biogeochemical and water cycles that affect the structure and composition of this
263 ecosystem. This cycle represents a large number of independent physical, chemical
264 and biological processes (Reddy and Delaune, 2008). One of these processes is the
265 climate. Dayat Morsli is under the influence of a semi-arid climate defined by the
266 Köppen-Geiger classification, with a dry season from June to September. At the
267 dayat, we observed two periods, different from the climatic seasons, defined from the
268 statistical analysis of all samples and all physicochemical and biological parameters:
269 a period 1(January to May; Fig. 11a) and a period 2 extending over most of the year
270 between June to December (Fig. 11b). However, the climate remains the most
271 important factor influencing the quality of the wetland surface water through the
272 balance of precipitation and evaporation. The impact of climatic variations on dayat
273 Morsli, particularly between the first five and last seven months of the year, is clearly
274 illustrated in Figure 11. The rainfall and temperature variations have induced a
275 significant decrease in the water level with drying borders and shrinkage in the dayat
276 area. The water volume evolution of the lake shows an important evaporation
277 (significantly negative correlation with temperature $p < 0.05$) with a decrease in lake
278 volume of 24% between the wettest month (March) and the driest month
279 (September). Under these conditions, the autumn rains fill mostly the underground
280 lack of water at the end of the summer and do not allow a significant increase in the

281 lake volume during this second period. Moreover, the arid regions tend to have
282 higher salt concentrations in surface waters than in humid regions (Williams and
283 Gosselink, 2007), a common phenomenon especially in endoreic lakes located in
284 countries known for their warm climate where the evaporation rate is higher than
285 precipitation, such as in the Mediterranean basin or in Central Africa (Jan and Lenka,
286 2008; Bouchez et al. 2016). Dayat Morsli is not immune to this phenomenon and
287 shows very significant salinity variations over the year.

288 Hydrology has an effect on salinity, the decrease of water in wetlands causes the
289 increase of salinity due to the concentration of ions in hot periods which forms a crust
290 on the surface of the wetland (Hart et al., 1990). This has an impact on the planktonic
291 and bacterial communities. The accumulation of organic matter in wetlands is
292 controlled by hydrology, through its influence on primary productivity, decomposition
293 and export of particulate organic matter. When the organic matter is decomposed,
294 microorganisms use organic substrates as an energy source. This process is
295 accelerated in aerobic conditions and becomes slower in anaerobic conditions
296 (Reddy and Delaune, 2008). Actually, the decomposition of organic matters in dayat
297 Morsli happens in period 1 in aerobic conditions while its accumulation and
298 sedimentation occurs during the period 2 at the same time as the decrease in water
299 level. This explains the spike of organic matter found in the Dayat during this period,
300 the same observations as in central Asia arid lakes (Ginatullina et al., 2017; Lin et al.,
301 2017).

302 Another parameter related to water quality in wetlands is the pH of the water. In
303 wetlands, the pH is mainly regulated by the photosynthetic activity of the flooded
304 phytoplankton and peripheral aquatic plants. This is directly related to the absence or
305 presence of carbon dioxide, the pH can then reach higher values during the day and
306 lower ones at night (Reddy and Delaune, 2008). In dayat Morsli, the pH is alkaline in
307 period 1 and neutral to acid in period 2. The increase in pH is explained by a large
308 number of phytoplanktonic cells, particularly with the occurrence of bloom in the
309 period 1, while in the period 2 it decreases due to a drop in the water level, in the
310 number of phytoplanktonic cells and consequently in photosynthetic activity. Actually,
311 between March and April there was the occurrence of a bloom identified as two
312 macroalga species *Ulva* sp. and *Mougeotia gracilis* and a microalga species
313 *Dunaliella salina*. The favorable environmental conditions, the increase in nitrates

314 and phosphates and the rise of the water level in dayat Morsli contributed to these
315 algal blooms. As the studies show, these diverse species have the ability to live in the
316 same conditions as in the Oran dayat (Frost-Christensen and Sand-Jensen, 1990;
317 Thakur and Kumar, 1999).

318 Nitrate and phosphates are essential elements for the development of photosynthetic
319 organisms. In wetlands, they are used by microorganisms and plants as mineral
320 sources, but at high concentrations they induce an ecosystem eutrophication and
321 blooms (Boeykens et al., 2017). In dayat Morsli, these two elements are closely
322 correlated, and well above the standard concentrations (Extract from the executive
323 decree, 2011; WHO, 2004; Sup. data S3). This is mainly due to the agricultural and
324 urban waste containing high concentrations of nitrates and phosphates, which have
325 been accumulated over time. These two elements are also related to the organic
326 matter decomposition and bacteria, especially the nitrificants bacteria of the water,
327 that also increase the NO₃ production (De Wilde et al., 2015; Gómez-Alday et al.,
328 2014). The high concentrations of nitrates, phosphates, as well as the water
329 alkalinity, induce the eutrophication of dayat Morsli, as demonstrated in studies on
330 polluted lakes in Kenya and Morocco (Jirsa et al., 2013; Lakhdar Idrissi et al., 2004).
331 The eutrophication increases sedimentation and thus degrades the aquatic system,
332 as well as problems related to different water utilizations (Heathcote and Downing,
333 2012; Jirsa et al., 2013; Lakhdar Idrissi et al., 2004).

334 For heavy metals, cadmium and lead are present in high concentrations in the dayat
335 Morsli water system (Extract from the executive decree, 2011; WHO, 2004; Sup. data
336 s3). Toxic metals without a biochemical role for phytoplankton can have adverse
337 effects due to their high bioaccumulation trend, and their origin is entirely
338 anthropogenic (industrial waste) (Pavlaki et al., 2016). Cadmium in nature is a
339 common under-product of zinc mining, which subsequently often flows into the
340 aquatic system, and is then found in brackish and marine environments (Nazeer et
341 al., 2014). During the first three months of the year 2017, there was a decrease in
342 cadmium and zinc levels in the water due to favorable conditions (alkaline pH,
343 increased numbers of cells) (Christensen, 1989; Ming et al., 2016), which may have
344 resulted in the sorbtion of Zn and Cd by planktonic organisms present in dayat Morsli,
345 particularly by the species that appeared during the bloom of the month of March and
346 April. As a matter of fact, the planktonic organisms have the ability to absorb and

347 assimilate heavy metals from the aquatic environment (Jia et al., 2018). The
348 cadmium is accumulated by plankton, but to a lesser extent than zinc which is
349 absorbed and metabolised by cells (Intwala et al., 2008; Lasenby and Van Duyn,
350 1992). Further research revealed that the presence of cadmium increased the uptake
351 of zinc in competitive manner and that plankton preferentially absorbed Zn (Sprenger
352 and McIntosh, 1989).

353 In addition to zinc, copper and iron are also essential elements for the development
354 of microorganisms; copper in dayat Morsli decreases in April until December. This
355 decline suggests that dissolved Cu is removed by organic matter particles and is
356 rapidly sedimented, due to its affinity to oxides and carbonates present in the water
357 column (Jackson, 1978). This organic matter present in natural water plays an
358 essential role in the transport of metals from the lake to sediments (Taher and
359 Soliman, 1999; Van Hullebusch et al., 2003). In the same way, a correlation between
360 heavy metals and surface organic matter has been demonstrated, as well as a
361 geochemical association of Cu and organic matter formed in Seliger Lake (Kosov et
362 al., 2004). For the iron analysis a marked increase in the aquatic environment
363 between March and May has been shown. This high concentration would indicate
364 that this metal is abundant in the soil of the wetland (Singh et al., 2007) and this iron
365 concentration decrease in the water could be due to the increase of nitrates and
366 phosphates in dayat Morsli. Actually, this decrease could be partly due to the iron
367 oxidation in the water and the formation of the Fe-PO₄ complex in sediments (De
368 Wilde et al., 2015).

369 In dayat Morsli the appearance and the disappearance of the algal bloom induced
370 changes in particular for zinc, iron and copper, three essential elements for the
371 development of microorganisms. These changes are observed before and after the
372 bloom. The decrease of these elements before the bloom appeared between January
373 and February and could be due to their absorption by planktonic microorganisms.
374 After the algal bloom, the zinc and iron increase in the water, although not
375 demonstrated, could be due to their release by planktonic cells, except for copper,
376 which sediments at the same time as cell residues and organic matter. In June, iron
377 and zinc sedimentation are linked to the water level decrease.

378

379 5. Conclusion

380 The study of dayat Morsli shows that this wetland varies in a uniform way over the
381 year and there is no difference between the seven sampling points. The
382 physicochemical and biological analysis in 2017 showed two successive periods
383 characterized by three main indicators. These are physicochemical and biological
384 parameters influencing the lake. In the wet season, the three highest indicators are
385 water level, cell abundance and pH. These variables decrease in the period 2, when
386 the three main indicators are the organic matter, the temperature and the salinity
387 which are at their maximum. The dayat Morsli suffered for many years from industrial
388 and urban waste pollution, which induced bioaccumulation of pollutants in this lake.
389 The heavy metal analysis of the water of this wetland showed cadmium and lead
390 pollution, with a respective average of 0.6 ppm and 0.9 ppm during the year. The
391 measured concentration of five heavy metals evolved according to the
392 physicochemical parameter changes, and there was a relationship between iron,
393 nitrates and phosphates, zinc and cadmium, and copper with the organic matter in
394 the wetland.

395 This first characterization of dayat Morsli provides a better understanding of the
396 functioning of this ecosystem and a description of the physicochemical and biological
397 parameter variations of the lake during the year 2017. All these results will make it
398 possible to establish a bioremediation initiative of this environment for its
399 rehabilitation.

400

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407 Sitography

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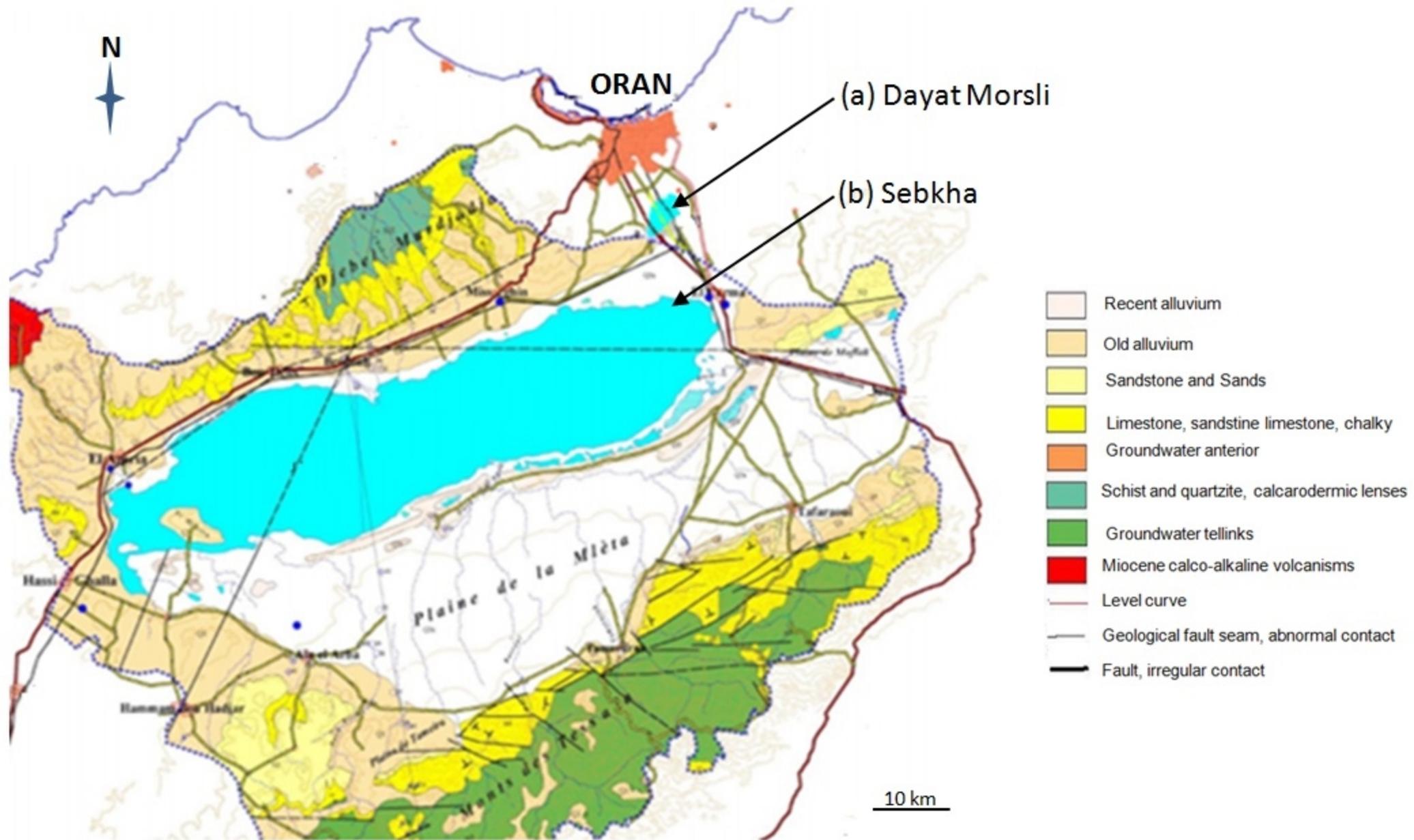
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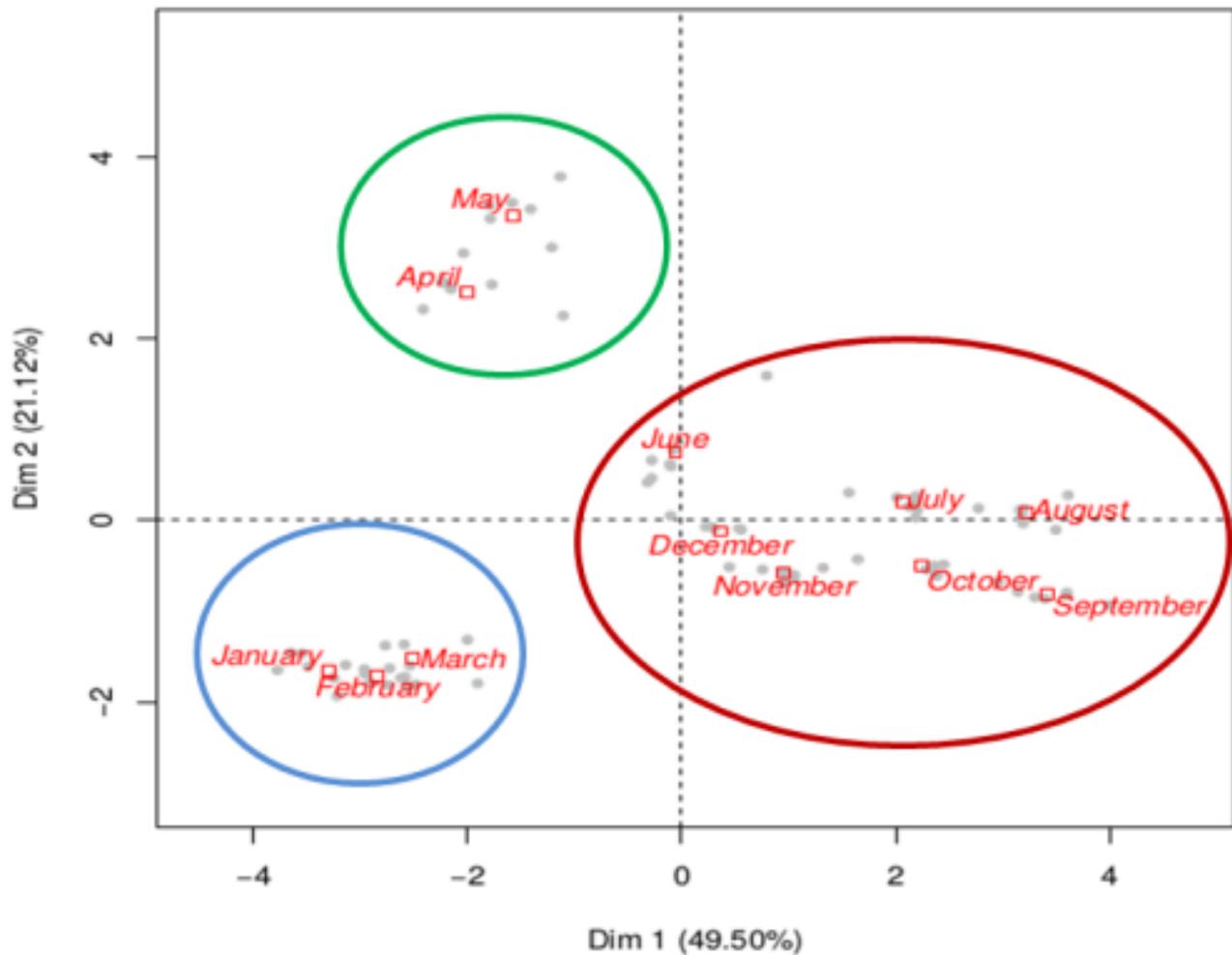
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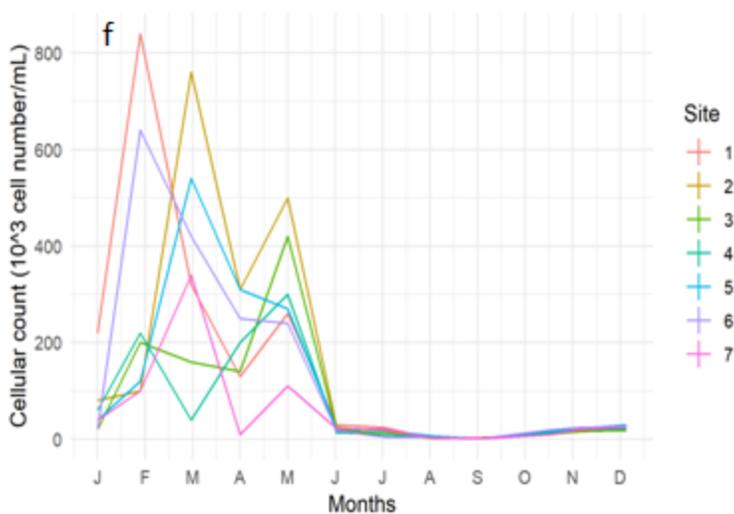
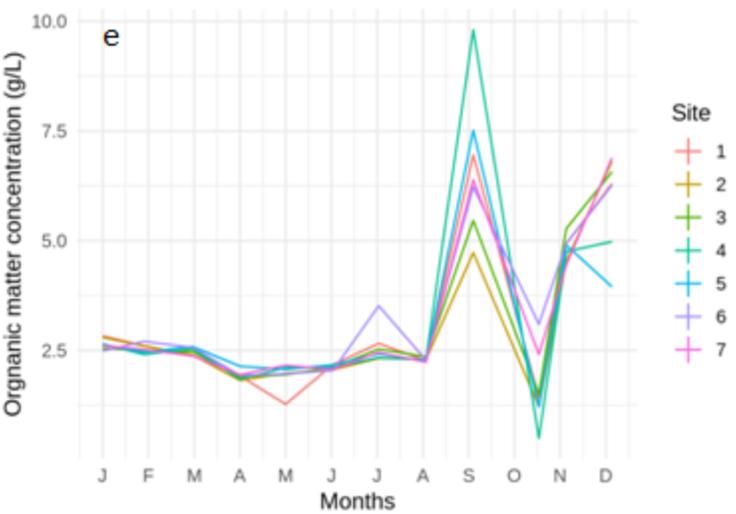
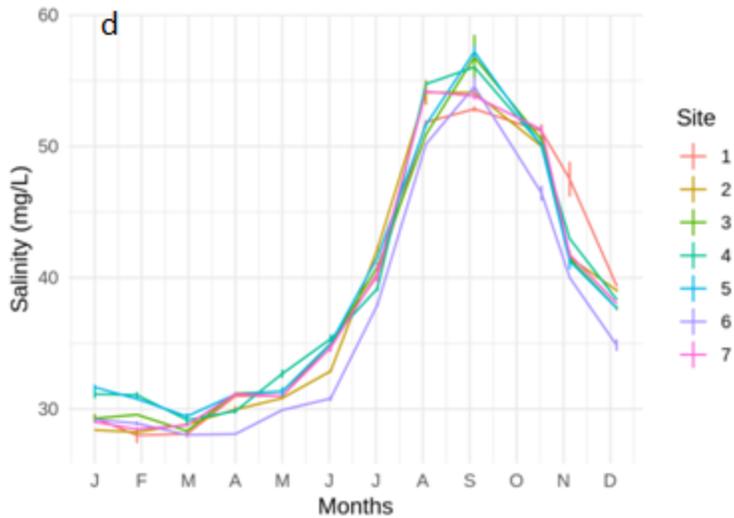
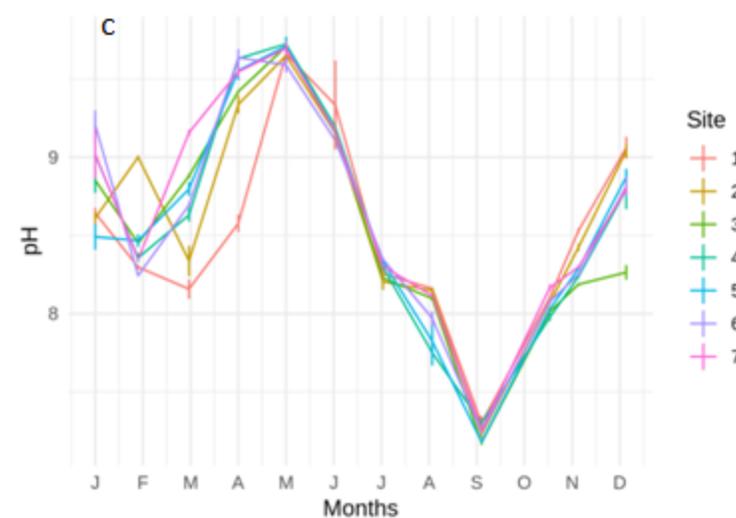
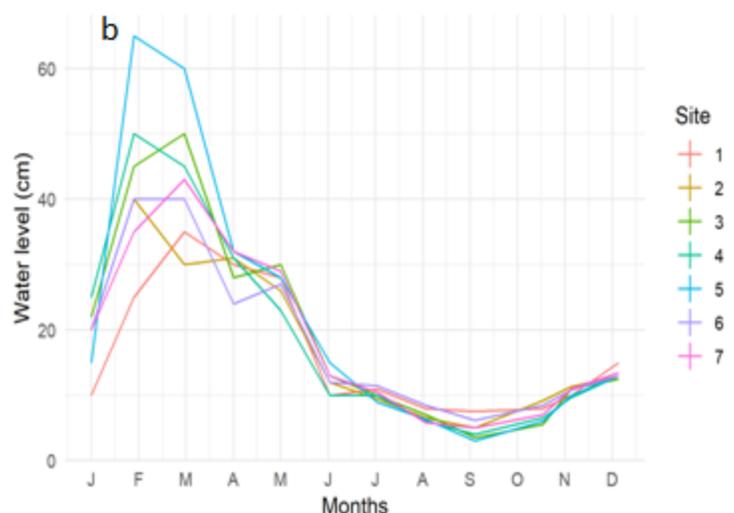
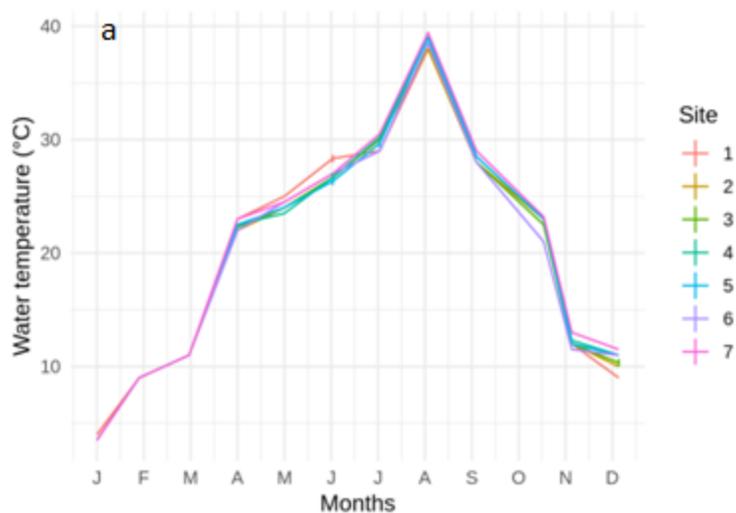
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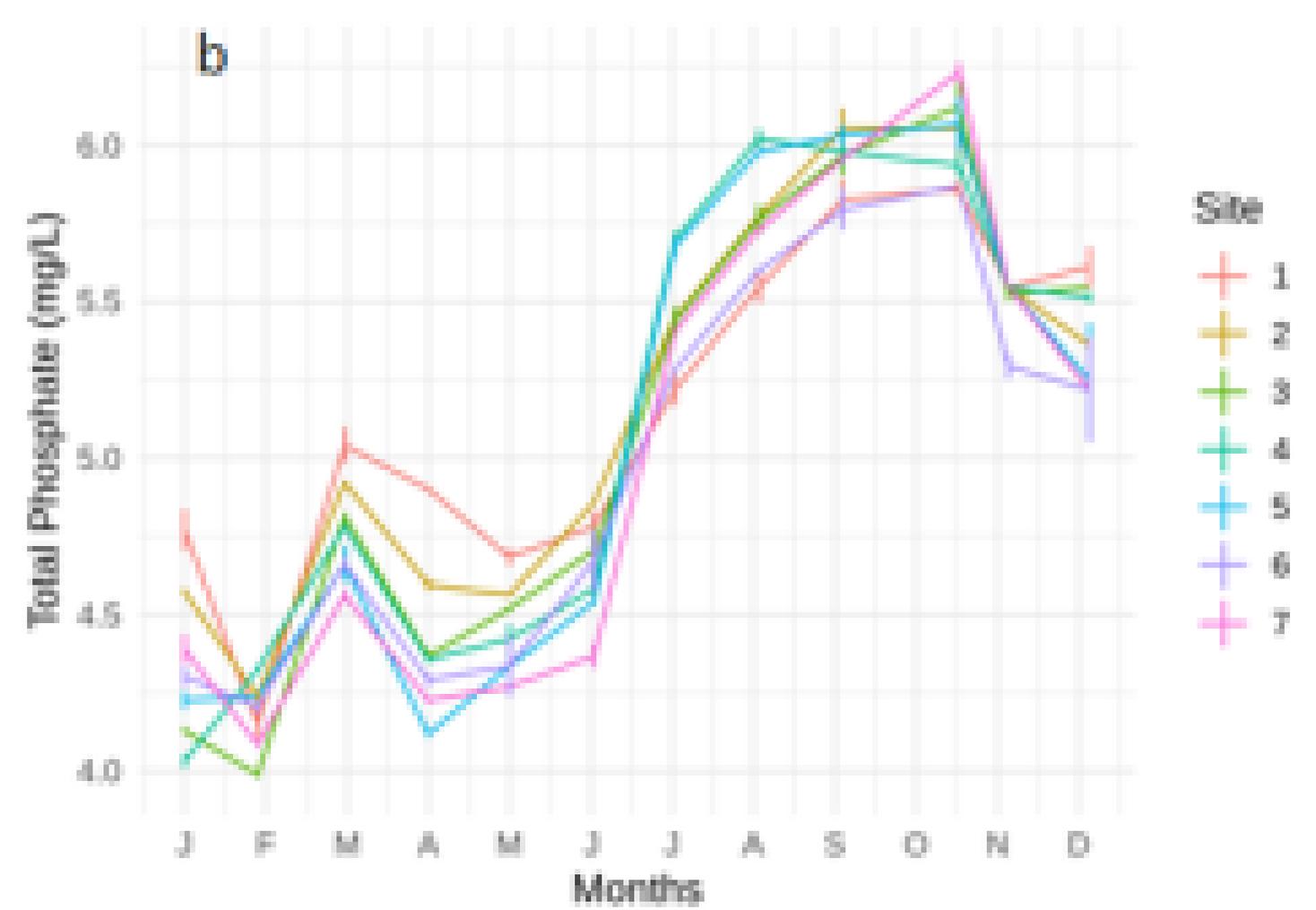
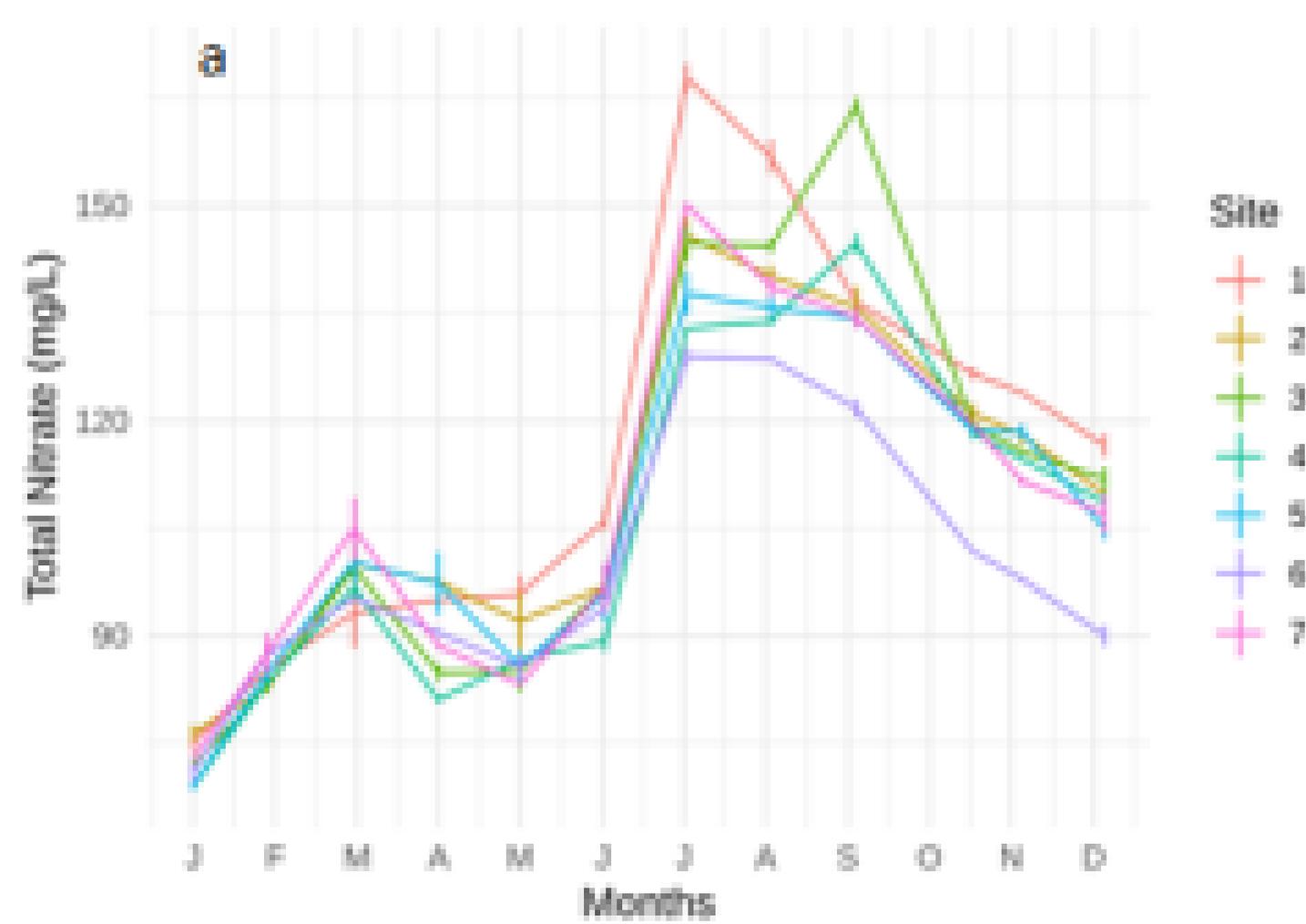
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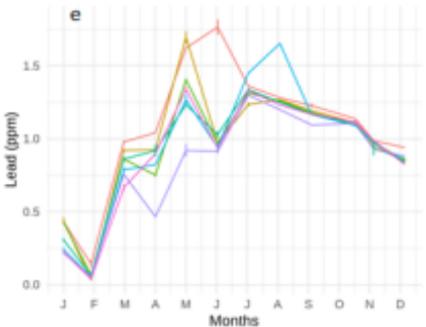
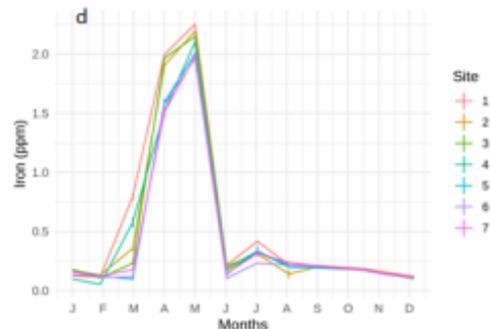
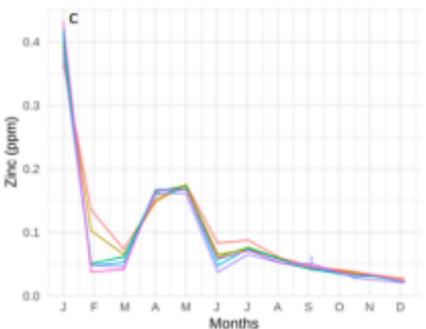
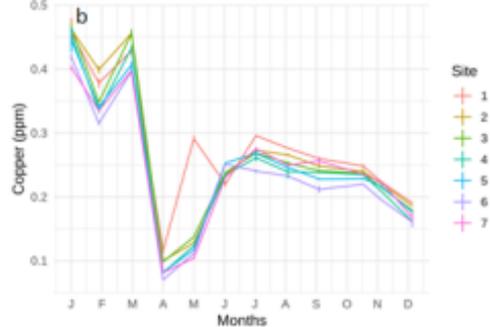
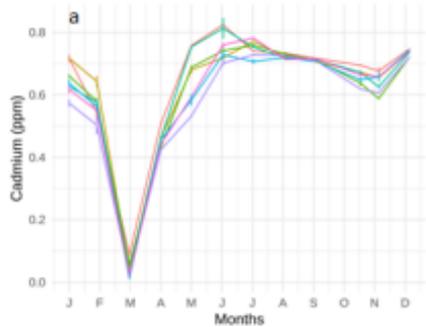


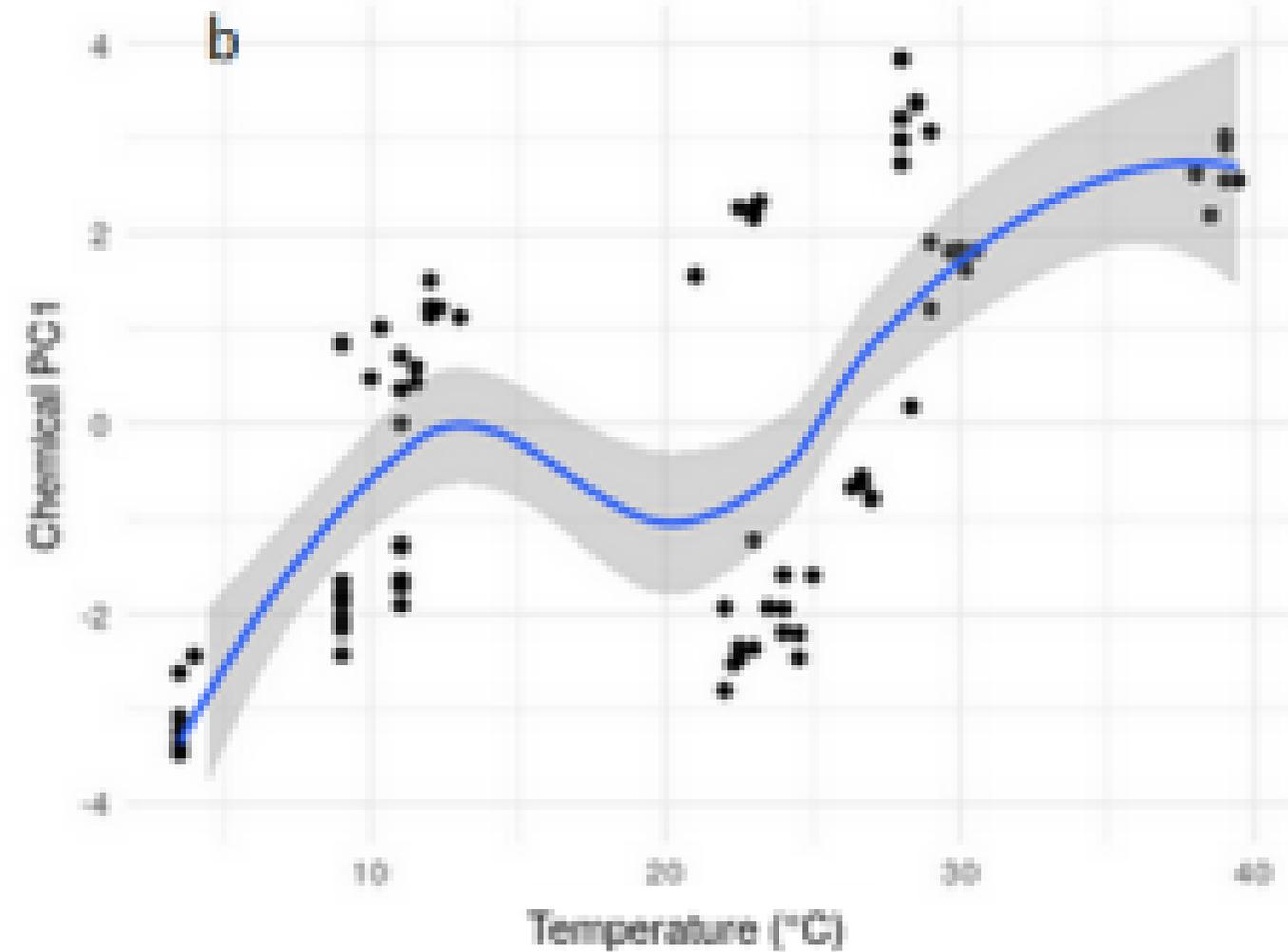
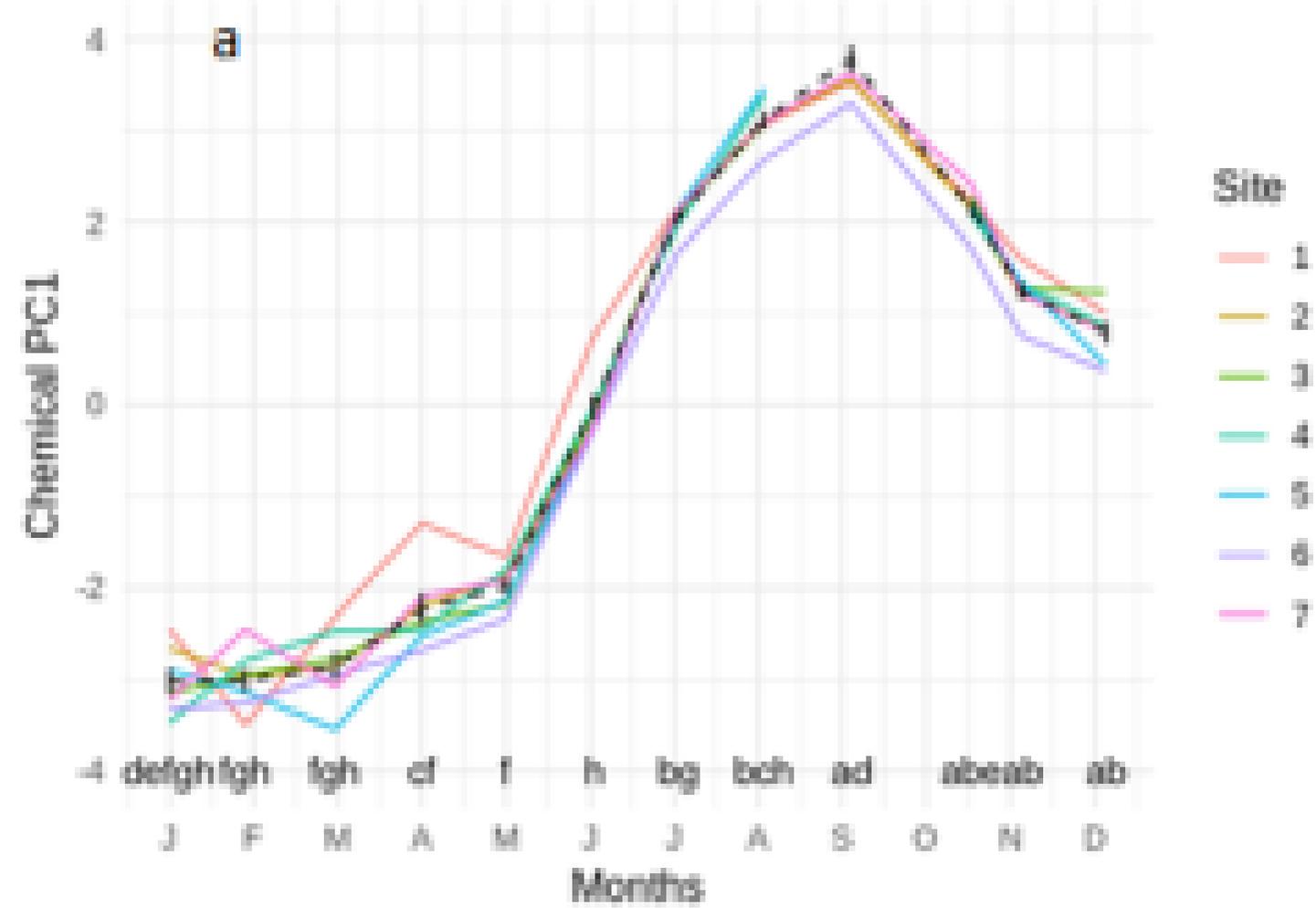


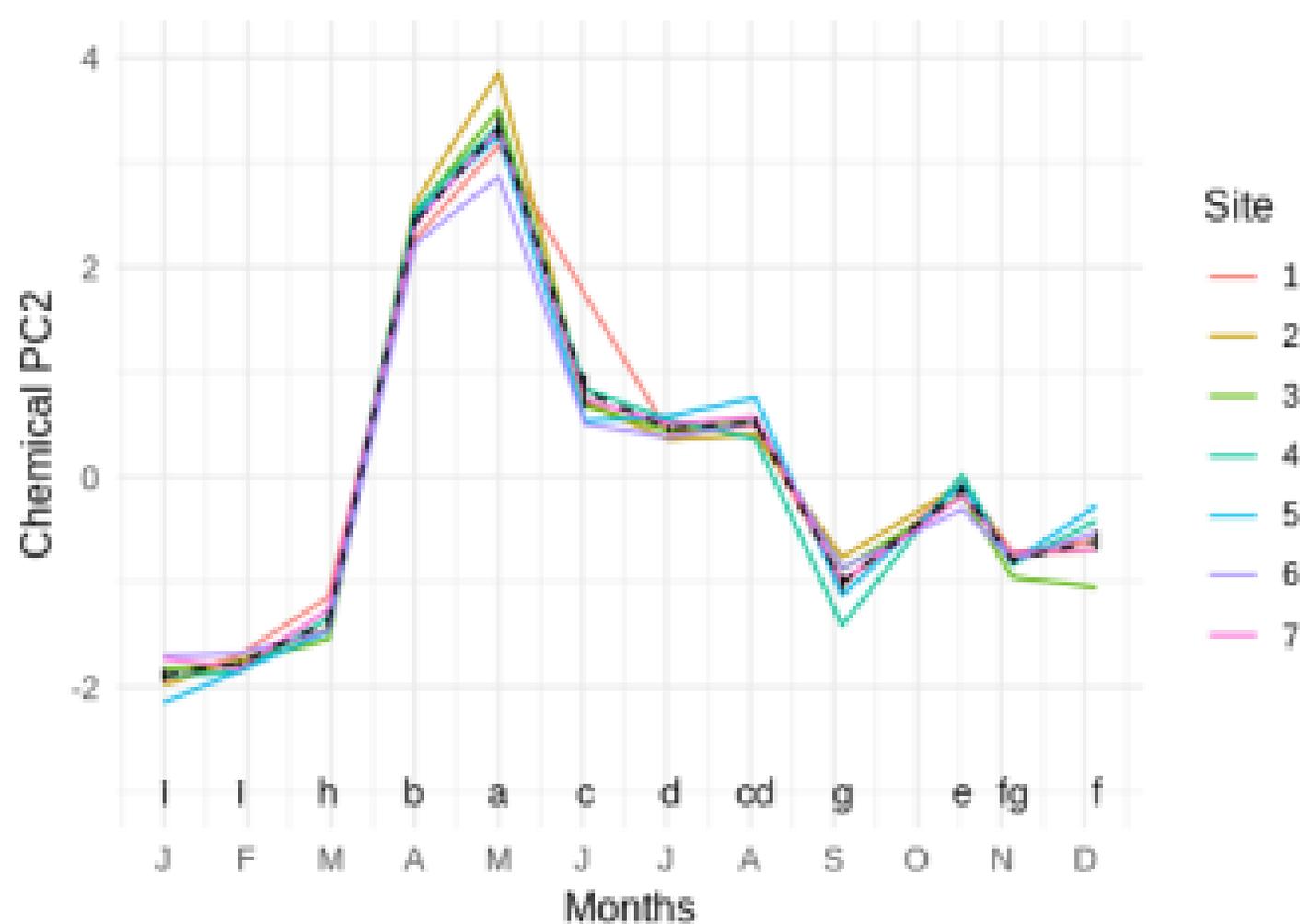


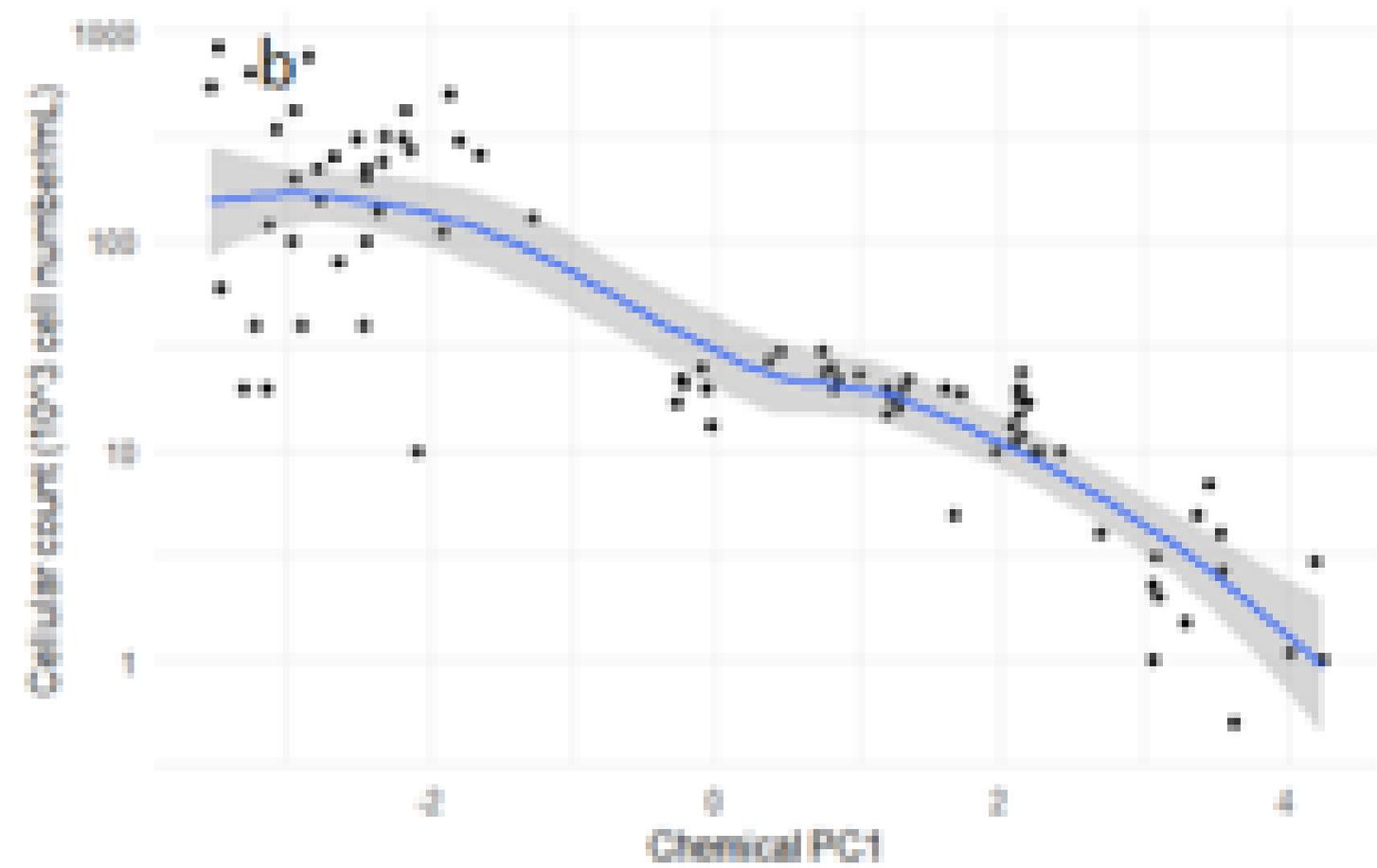
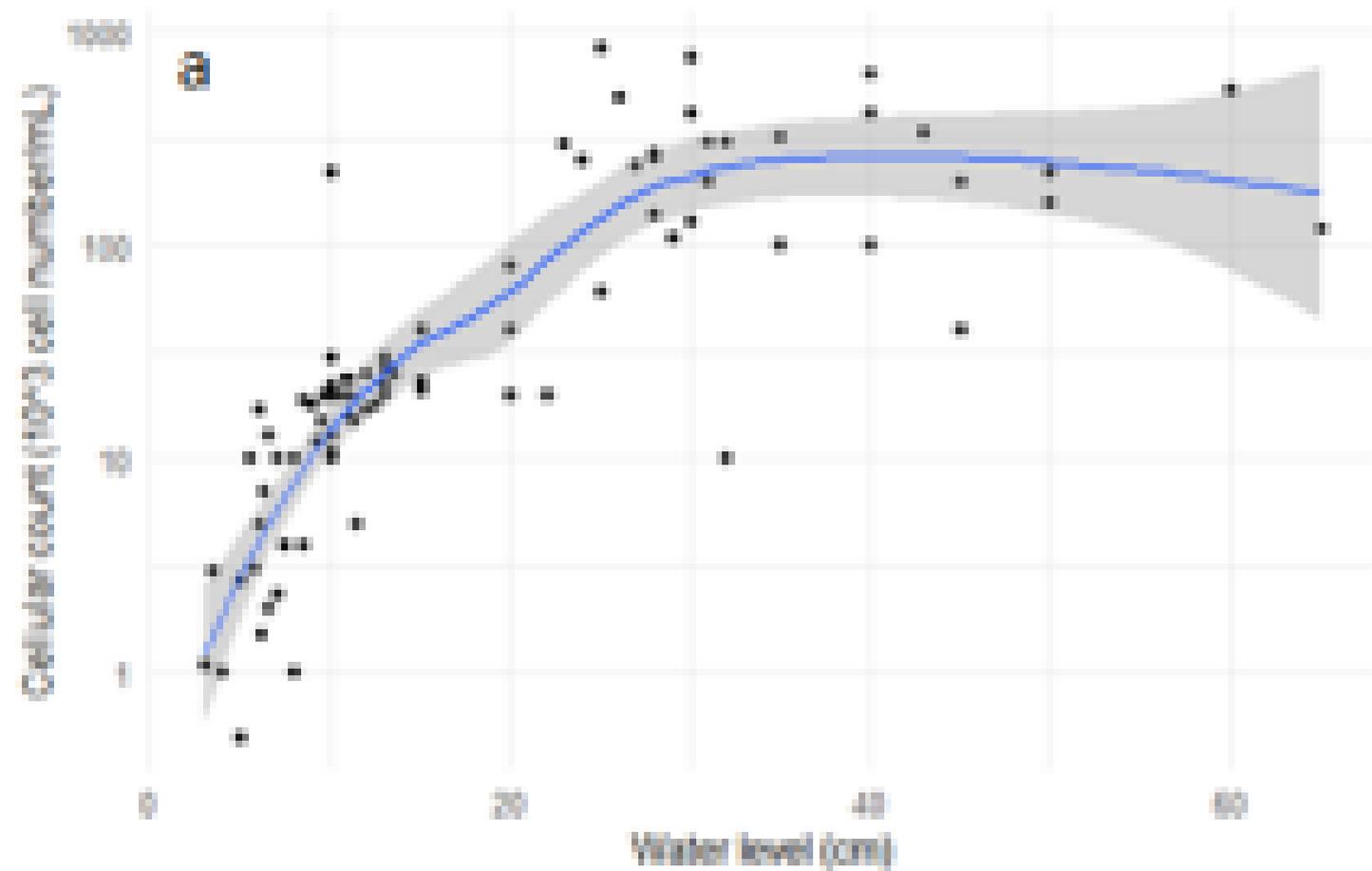




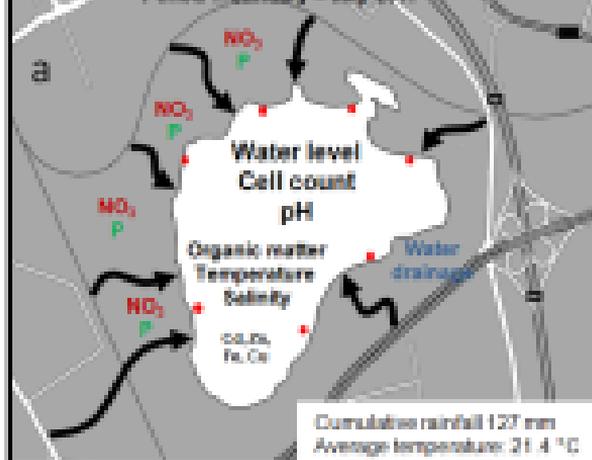








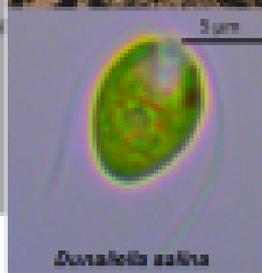
Period 1: January – May 2017



Dunaliella bloom



Macroalgae bloom



Period 2: June – December 2017

