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Main Geoenvironmental Studies to Launch New Medical Spa: The Case of the SãoTiago Medical Spa

Luis Manuel Ferreira Gomes

Department of Civil Engineering and Architecture, Beira Interior University, Covilhã, Portugal

Abstract: In order to have a new Medical Spa in Portugal, a new natural mineral water must first be officially registered and submitted to medical-hydrological studies that prove the therapeutic indications of that water, so that it can be used in health activities. For a groundwater to be classified as natural mineral water, a wide range of geoenvironmental studies must be carried out and several bureaucratic procedures must be developed to propose to the State the recognition of that resource as natural mineral water. The present work corresponds to a recently licensed natural mineral water, with application in medical spa activity (health and wellness), and that after its licensing was named "Termas de São Tiago". It is emphasized that there was no pre-existence of ancient Medical Spa on the site. Thus, in this paper the main aspects that led to the licensing of the new natural mineral water are presented, in particular, the geomorphological, geological, hydrogeoenvironmental aspects and the quality of the resource. With those unpublished technical elements, it was possible to sequence other medical studies, which together led to the current reality, which is the fact that in a place in the interior of Portugal (Penamacor), there are new Medical Spa in association with a new Hotel, which together will help to leverage the local economy that has been in decay, due to local depopulation.

Key words: groundwater, natural mineral water, water resource, São Tiago Medical Spa, Penamacor-Portugal

1. Introduction

The first hydrogeological prospecting works, with the aim of building a Medical Spa in the town of Penamacor, were carried out in 2011, following the need to build a Hotel in Quinta do Cafalado (southern edge of the Penamacor urban network), in order to contribute to increase tourism in the region. However, the investor understood that there would be more success in the project, if at the same time a medical spa was built in association with the hotel. The challenge was launched, and such situation led to several works of prospecting and hydrogeological research, which among others, led to the construction of a groundwater abstraction, Well P1 [1], with potential of its resource to be licensed as natural mineral water, to apply at a medical spa.

In the follow-up, several studies were carried out, deserving reference the work entitled "Hydrogeological study for direct attribution of concession as Mineral Water in thermalism activity — Termas de São Tiago – Penamacor" [2], being the same, the fundamental document for the Portuguese government to license the new natural mineral water: Termas de São Tiago.

According to the Portuguese legislation [3], for a groundwater to be licensed as natural mineral water, a process has to be constituted, associated with a request addressed to the Minister, with a set of documents, namely an original hydrogeological study, which includes within it, among others, the results of physical-chemical and bacteriological analyses, of the groundwater from a abstraction, which prove its quality and stability.

Corresponding author: Luis Manuel Ferreira Gomes, Associate Professor; research areas/interests: environmental geotechnics; hydrogeology, groundwater resources, geothermics. E-mail: lmfg@ubi.pt.

The study area is located immediately south of the urban area of the border town of Penamacor, located in the municipality of Penamacor, about 47 km to NE of its district capital, Castelo Branco, in the centre-interior region of Portugal (Fig. 1).

2. General Methodology

The work began with the geomorphological analysis of the territory surrounding the planned site for a new hotel and where there was interest in building a new medical spa.

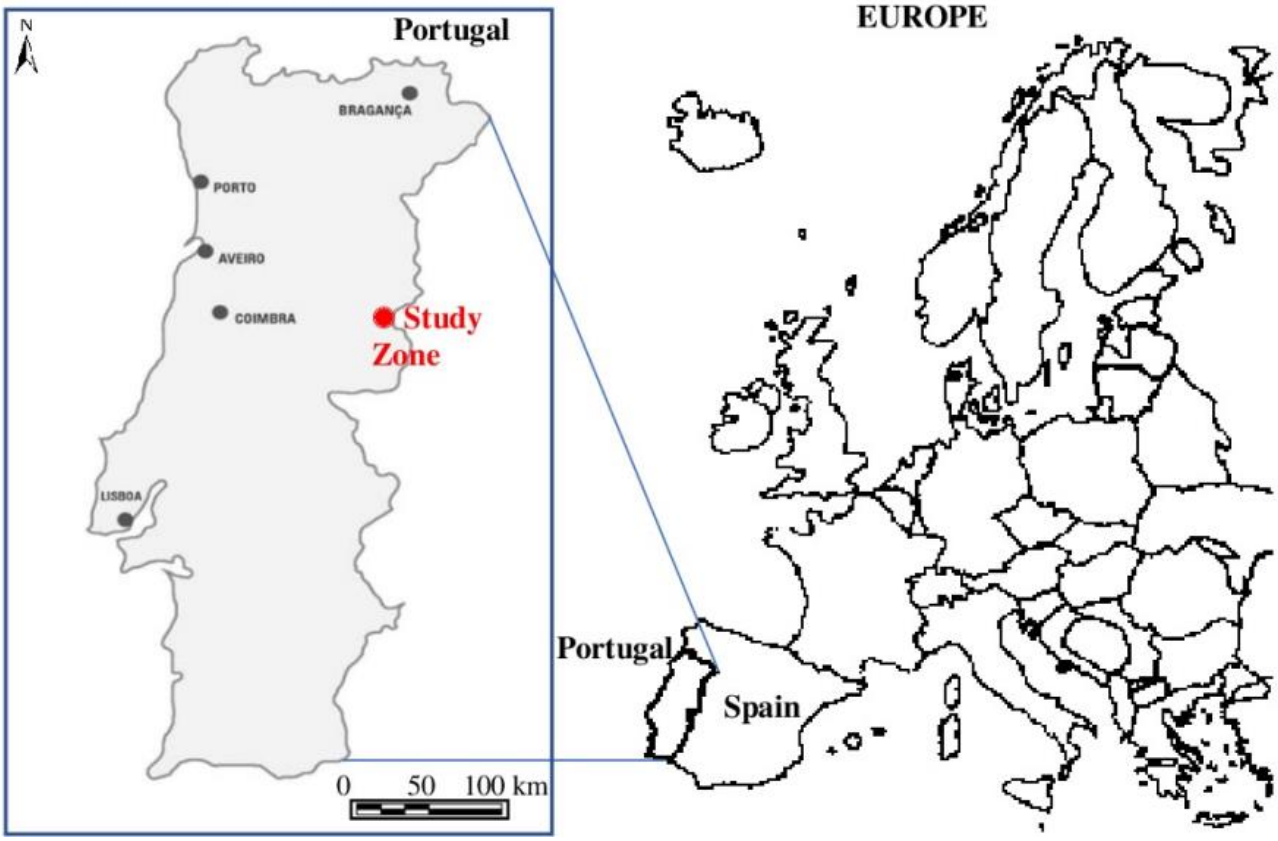

Fig. 1 Location/geographic framing of São Tiago Medical Spa (study zone), in the centre-interior region of Portugal.

In a first phase office work was carried out, crossing available maps, topographical and geological, in order to establish an area of the territory to study in some detail and specially to make a field survey of the various water points. The areas shown in Fig. 2, selected as sub-basins, "of the water line for the groundwater abstraction, contiguous and of proximity" were studied with detail.

In the follow-up, the main water points were recorded: type (spring, well, borehole, mine and others), depth, water table, flow, pH, Eh, conductivity, temperature and total dissolved solids. In view of the analysis of the results, 6 mechanical prospecting holes of roto-percussion type were programmed, of which only 3 were performed, because positive results were obtained, especially in Hole P1, which was transformed into groundwater abstraction.

After the completion of the groundwater abstraction, a pumping test was carried, and the allowable flow rate was defined, which served as a reference in the groundwater quality research period, performing summary physical-chemical and microbiological analyses on a monthly basis, for 12 consecutive months, in addition to other specific research, such as the analysis of trace chemical elements, radioactive substances, gases, pesticides and hydrocarbons.

Finally, because it proved to be an adequate resource to be licensed as natural mineral water, the original

hydrogeological report [2] was carried out, the main elements of which are presented in this paper, and having completed the bureaucratic procedures in this sense, the Portuguese State granted the licensing of the new mineral water, in 2016.

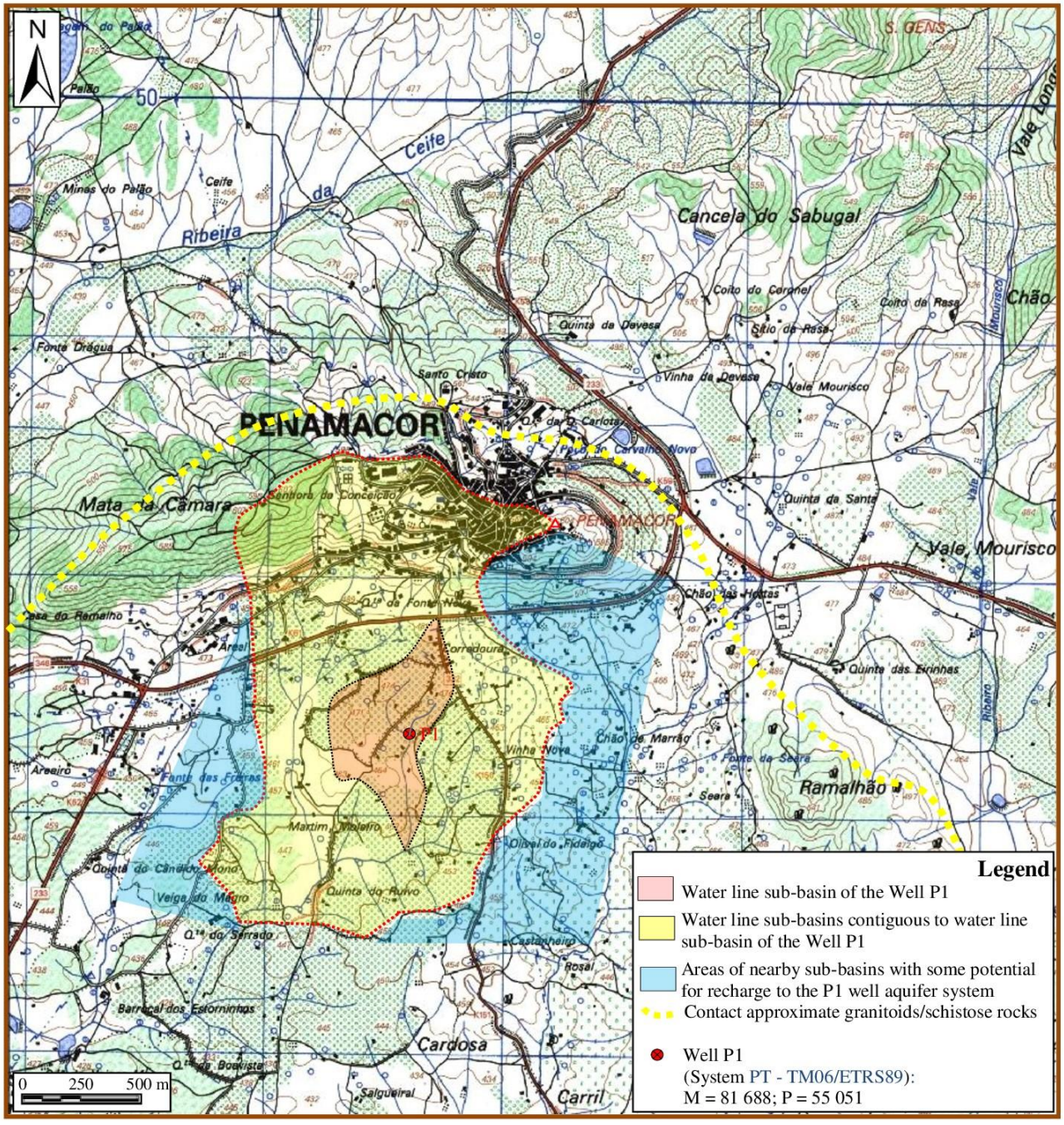

Fig. 2 Framework of the abstraction (P1 Well) in relation to the hydrographic sub-basins of the Penamacor region (adapted from military maps [6].

3. Geomorphological Aspects

The area where the abstraction (Well P1) of the new natural mineral water occurs, has an altitude of about 460 m, in almost flattened area, near the confluence of two water lines, very smalls, and only of first stream order, according to Strahler's classification[4]; the water line resulting from the previous ones moves

south (Fig. 2), confluencing at about 6 km, with the Taliscas stream, which in turn, converges with the Pônsul River, which is a tributary of the Tagus River, by its right bank, at Malpica do Tejo.

The area where the P1 Well is located is in the geomorphological unit called "Planura de Castelo Branco" [5], which contrasts with the unit "Cordillera Central", well known to include the Serra da Estrela, which is the highest mountain in continental Portugal (1993 m asl), north of Penamacor. The sub-basin of greatest interest for capturing groundwater and to preserving its quality is generally included within a rectangle of only 500 m by 900 m, with the largest side according to the development of the most extensive water line (Fig. 2), with higher altitude in the order of 483 m, and lower in the area of the P1 Well, with 461 m. That area is involved laterally and in particular to the west and east by other contiguous sub-basins, with development upstream, up to the urban area of Penamacor and at altitudes of the order of 605 m. The distance from the location of P1 Well to the most upstream area is in a straight line, about 1200 m.

4. Geological Aspects

The regional geological framework of the area where P1 Well is located is shown in Fig. 3, and it should be noted that the abstraction is installed in the Penamacor/Monsanto granite pluton (Unit γ^{II}_{3b}), which is involved for formations of the Schist-metagreywacke complex (Unit C_{BI}). The Penamacor/Monsanto granite pluton is essentially composed of two-mica porphyroid granites, generally with hydrothermal alteration. It emphasizes the fact that the Pluton is crossed by two extensive geological faults, with NE-SW direction (Fig. 2), understanding that they will be important in the recharge of the aquifer systems in depth. It is important to mention that the meteoric alteration affects pluton intensely, with large areas being quite sandy.

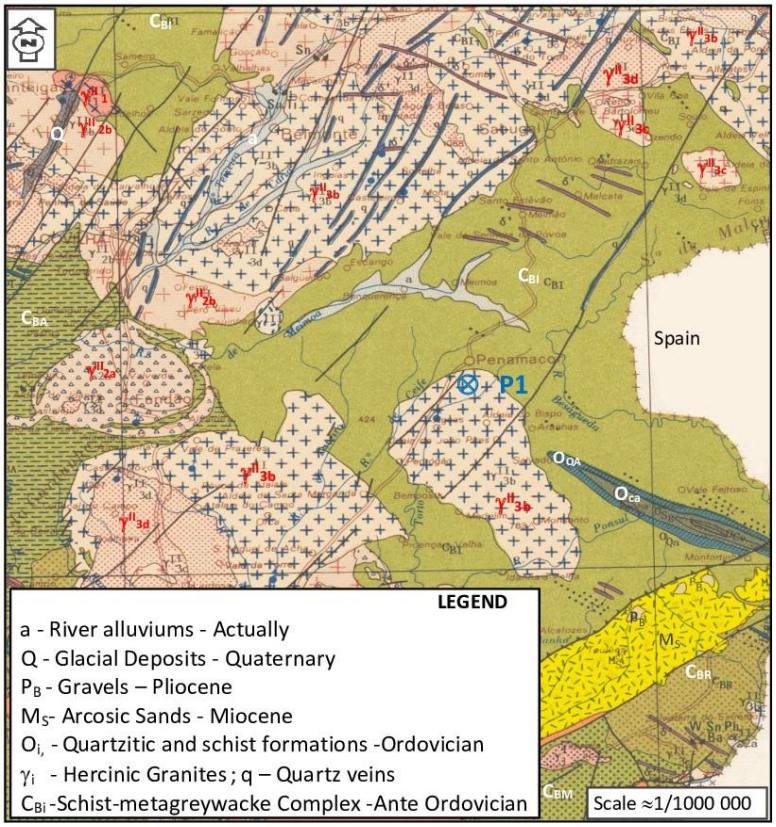

Fig. 3 Regional geological framing of the site of Well P1, which serves the São Tiago Medical Spa (in extract of the Geological Map of Portugal [7].

The local geological sketch of the area of greatest interest to the abstraction area of the groundwater in study is shown in Fig. 4; it should be noted that the units that are preponderant to the present study are: i) river alluviums- recents; ii) Hercinic granites; and iii) Schist-metagreywacke complex - ante Ordovician.

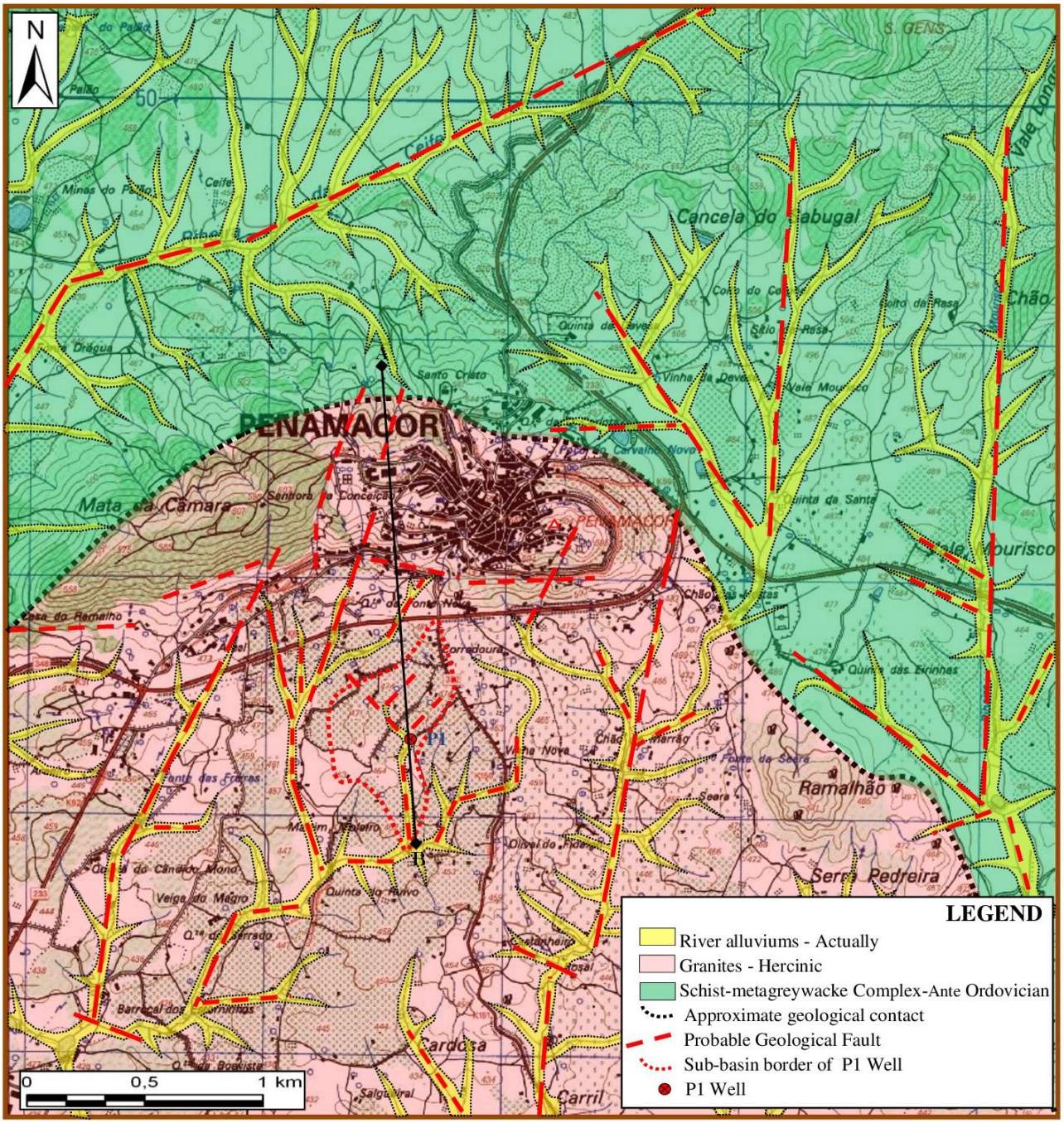

Fig. 4 Local geological sketch of the study area - São Tiago Medical Spa region, Penamacor.

The river alluviums are not very thick, generally with thicknesses below 5 m, and are essentially sandy, of extensive granulometry, with the coarsest fraction predominating. The granites, fundamental to the aquifer system under study, have medium to coarse grains, with little alteration in the urban area of Penamacor, i.e., in the higher areas, and very coarse grains, porphyroids, with two-mica, generally very altered and sometimes

even sandy in the lower areas, including the area where the abstraction (P1 Well) is installed. The Schist-metagreywacke complex is understood to have no significant importance in the context of this study.

Still from a geological point of view, it is important to point out that the granite massif, and especially in the higher areas, urban area, is extremely fractured, besides occurring some relatively extensive faults in predominant NNE-SSW directions; these situations favor deep water recharge in order to supply the groundwater abstraction area.

5. Hydrogeoenvironmental Aspects

5.1 Climatic and Hydrological Elements

In order to get a notion of the groundwater recharge potential for the region under study, some climatic aspects of the area that are intended to influence groundwater recharge in depth were studied, according to the records of precipitation and temperature elements corresponding to measurements for about 30 years in a row.

Thus, considering the average daily temperatures of each month, during the year, as well as the monthly precipitations (Table 1), the monthly sequential hydrologic balance was performed using the methodology proposed by Thornthwaite and Mather [8], whose graphic form is presented in Fig. 5.

From the results of the hydrological balance made for the region under study, the following main conclusions

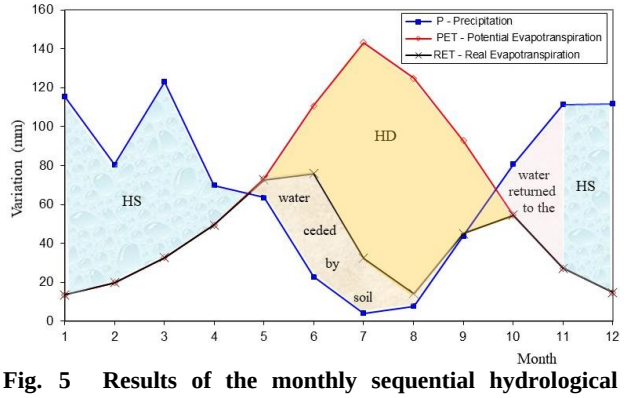

Fig. 5 Results of the monthly sequential hydrological balance for the region of São Tiago Medical Spa – Penamacor.

can be drawn: i) there is a dry period and a wet period; the first is translated by the hydric deficit (HD), which goes from May to September while the second period, the wet period, is translated by the hydric superavit (HS), which goes from October to May of the following year; ii) HD reaches its maximum value in July and August; iii) HS reaches its maximum value in January.

The total annual HS was 382.5 mm, and it should be noted that it results in two parts: surface runoff (R) and underground runoff (G), i.e.: HS = R + G = 382.5 mm.

5.2 Water Points

An inventory was made of 31 water points, consisting essentially of wells, boreholes and occasionally a spring. It should be noted that the fundamental objective was to know the type of resource of each water point, in order to clarify the hydrogeological model with the greatest possible consistency. The measured in situ parameters were, whenever possible, the following: depth/length of abstraction, depth of water level in it, flow rate, pH, conductivity (C), temperature (T), total dissolved solids (TDS) and resistivity (ρ). Detailed records were presented in Ferreira Gomes [2]. Of the results obtained, those of the resource of P1 Well are highlighted, as it was the abstraction that became the basis for the licensing of the new mineral water, so as to serve as a reference to the results of the other water points, being the following: pH=6.6; C =198.2 μS/cm; T = 17.8°C; TDS = 187.2 mg/L; ρ = 2.47 k Ω.cm.

In relation to the other water points there are some variety of situations, which are systematized as follows:

i) group of water points that appear to have their resource similar to, or close to, that of the P1 Well; these have c in the order of 160 to 220 μS/cm, pH in the order of 6.3 and T of 18°C; these waters are associated with fissural aquifer of depths greater than 100 m, and may be associated with fractures filled with silica and some metallic elements, as there is the situation that in some cases the waters are slightly iron;

ii) group of water points that present less mineralization than the P1 Well, and that occur in areas

of the superficial aquifer (unconfined); these have c in the order of 60 to 92 μS/cm, pH of 5.6 to 6.0 and T around 15 to 16°C; these waters are associated with the aquifer essentially of the porous type, due to the granites being very altered, and to depths generally below 50 m.

Table 1 Statistics of the results of physical-chemical analyses of groundwater from the P1Well carried during a hydrological year with the objective of its legalization as natural mineral water.

Parameter		Nº. of analyses	minimum	average	maximum	Standard Deviation-SD	$SD_{Relative}$ (%)
pH (*1)		12	6.51	6.72	6.88	0.12	1.8
Conductivity ($\mu S.cm^{-1}$) (*1)		12	185.0	191.8	199.0	4.84	2.5
Total Alkalinity - mg ($CaCO_3$/L)		12	82.2	87.3	93.1	2.92	3.4
Total sulphide (mL I_2 0.01 N / L)		12	< 3.0	-	< 3.0	-	-
Silica (mg/L)		12	50.0	51.6	53.0	1.19	2.3
Hardness - $CaCO_3$ (mg/L)		12	61.0	65.4	69.0	2.66	4.1
Dry residue at 180°C (mg/L)		12	156.0	160.8	165.0	2.80	1.7
Total mineralization (mg/L)		12	207.0	214.4	222.0	4.46	2.1
Cations (mg/L)	Na^+	12	16.0	17.1	18.6	0.73	4.3
	Ca^{2+}	12	12.8	13.6	14.5	0.54	4.0
	K^+	12	1.2	1.3	1.4	0.08	5.8
	Mg^{2+}	12	6.7	7.7	8.1	0.38	4.9
	NH_4^+	12	0.00	<0.05	-	<0.05	-
	Li^+	12	0.10	< 0.10	-	0.11	-
	Fe^{2+}	12	1.9	2.6	3.1	0.31	11.8
Anions (mg/L)	HCO_3^-	12	99.3	105.6	113.0	3.55	3.4
	CO_3^-	12	< 2.0	-	< 2.0	-	-
	Cl^-	12	8.2	8.6	8.9	0.20	2.3
	SO_4^{2-}	12	5.0	5.9	6.7	0.44	7.4
	F^-	12	0.9	1.0	1.2	0.07	7.2
	NO_3^-	12	<0.3	-	2.6	-	-
	NO_2^-	12	<0.010	-	<0.010	-	-
	SH^-	12	<0.5	-	<0.5	-	-
Vestigiary elements (mg/L) x 10^{-3}	Ag	1	-	<1.0	-	-	-
	Al	1	-	6.0	-	-	-
	Ba	1	-	<30	-	-	-
	Be	1	-	0.60	-	-	-
	Br	1	-	< 100	-	-	-
	Cd	1	-	<1	-	-	-
	Co	1	-	<2	-	-	-
	Cr	1	-	<1.0	-	-	-
	Cs	1	-	5.2	-	-	-
	Cu	1	-	<2	-	-	-
	Hg	1		<0.2		-	-
	I	1	-	7	-	-	-
	Mn	1	-	540	-	-	-
	Mo	1	-	<5.0	-	-	-
	Ni	1	-	<5.0	-	-	-
	Pb	1	-	<3.0	-	-	-
	Sb	1	-	<5	-	-	-
	Se	1	-	<0.4	-	-	-
	Sr	1	-	39	-	-	-
	U	1	-	1,8	-	-	-
	V	1	-	<10	-	-	-
	W	1	-	<1,0	-	-	-
	Zn	1	-	<50	-	-	-

(*1) values relating to the temperature of 20°C; Note: The values that appear with "<" mean that they are below the quantification limit

iii) group of water points that have resources from depths greater than 100m, but that are close to contact with the schistent rocks; they have c of 250 to 535 µS/cm, pH of 6.13 to 6.50 and T of 15 to 18.5°C, depending on the depth of capture; points with these characteristics already occur outside the main sub-basin of the P1 Well and it is admitted that they can also occur in the urban area of Penamacor and especially to the north of it; these waters normally have iron;

(iv) group of water points generally contaminated; these points are distinguished from others by being associated with sites that would initially fit into the other groups but often have conductivities above what is considered normal.

5.3 Groundwater Abstraction - Well P1

The abstraction, called P1 Well, is the result of a vertical hole, performed in 2011 [1], with the drilling of the rotopercussion type. The hole was 324 m deep; excluding the approximately 2 meters more superficial with vegetal soil/alluvium, it crossed always porphyroid granite of coarse biotite-muscovite grain, with different weathering degrees: from 2 to 4 m depth, very altered (W4/5), light brown; from 4 to 61 m depth, altered (W3), very light brown; from 61 to 319 m depth, slightly altered (W2), very light grey; from 319 to 324 m depth, unaltered rock (fresh rock) (W1), light bluish grey. The water table was detected at a depth of 3 m, with flow records in drilling phase of 0.15 L/s between 3 m and 65 m, 1.2 L/s between 65 m and 80 m and 2.0 L/s from 80 m depth. The piezometric level stabilized at the end of the drilling work was 1m deep.

The final geometry of the P1 hole is shown in Fig. 6. It should be noted that the hole was completely isolated from the surface to 25 m depth, gravel in the annular space between 25 and 101 m, and drain pipe between 81 and 101 m, i.e., water only enters the hole below 81m deep; for depth below 101 m, the hole was in open-hole, therefore without the need for any support.

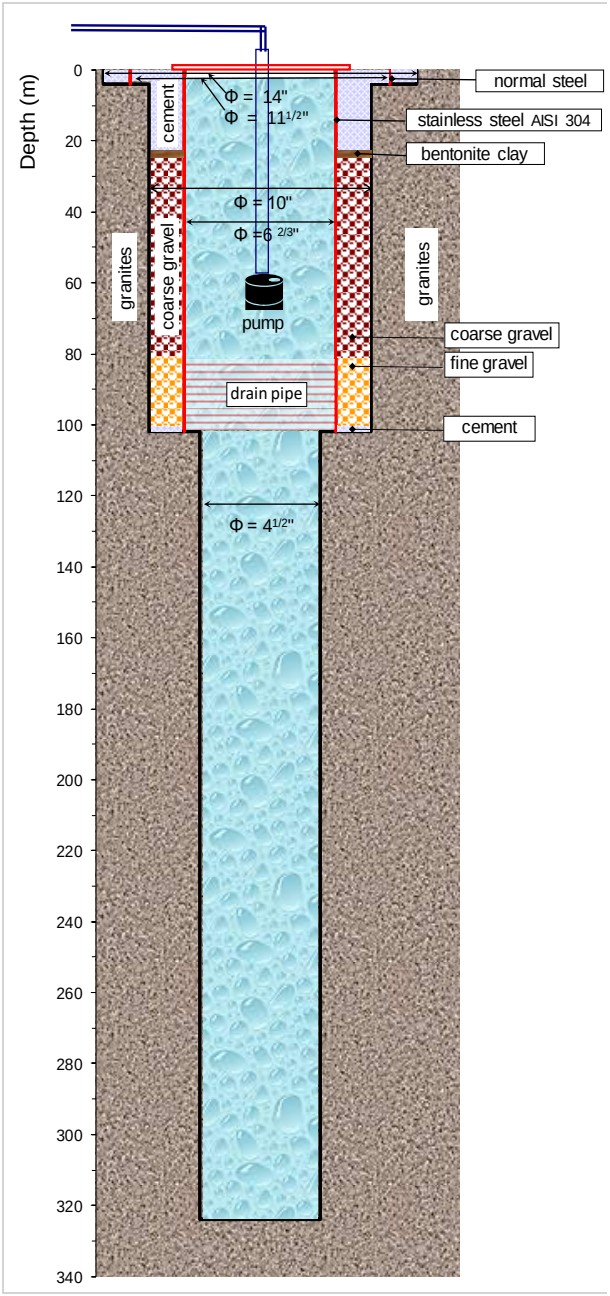

Fig. 6 Final Geometry of the P1 Well that supplies SãoTiago Medical Spa - Penamacor.

Meanwhile, a pumping test with submersible pump was performed on 9.06.2011. The results obtained and the resulting graphs are shown in Fig. 7. By interpreting the characteristic curve, and taking into account the author's experience, it is understood that in the exploration regime, the allowed flow (Q_{adm}) should not exceed 0.7 L/s, causing drawdowns of the order of 32 m.

Pumping Test - P1 Well: direct results a)

Date	Hora	Time (min)	Parameters in P1 Well							
			Q(L/s)	WL(m)	s (m)	T (ºC)	pH	Eh	c (µS/cm)	TDS (mg/L)
09/06/2011	13:12	0	0,00	1,20	0,00	18,0	7,2	-37,8	307,10	281
	13:12	0	0,20	1,20	0,00					
	13:13	1	0,20	3,50	-2,30					
	13:14	2	0,20	4,50	-3,30					
	13:16	4	0,20	5,10	-3,90	18,2	7,3	-40,5	290,40	267
	13:20	8	0,20	5,30	-4,10					
	13:25	13	0,20	5,40	-4,20	17,7	7,3	-40,1	292,30	269
	13:30	18	0,20	5,45	-4,25					
	13:35	23	0,20	5,50	-4,30	17,7	7,2	-38,9	288,20	265
	13:40	28	0,20	6,00	-4,80					
	13:42	30	0,20	6,10	-4,90	17,8	7,2	-37,8	286,9	264
	13:42	30	0,40	6,10	-4,90					
	13:43	31	0,40	7,00	-5,80					
	13:45	33	0,40	7,50	-6,30					
	13:50	38	0,40	8,12	-6,92	18,2	7,2	-38,6	285,40	263
	13:55	43	0,40	9,03	-7,83	18,3	7,2	-37,2	286,20	263
	14:00	48	0,40	10,15	-8,95	18,3	7,2	-38,5	285,90	263
	14:10	58	0,40	11,25	-10,05	18,5	7,2	-38,8	284,30	261
	14:20	68	0,40	12,25	-11,05	18,8	7,2	-38,6	282,90	264
	14:30	78	0,40	12,95	-11,75	18,5	7,2	-35,7	284,20	261
	14:35	83	0,40	13,09	-11,89					
	14:40	88	0,40	13,50	-12,30	18,5	7,2	-34,7	282,60	260
	14:45	93	0,40	13,58	-12,38					
	14:45	93	1,00	13,58	-12,38					
	14:48	96	1,00	13,69	-12,49					
	14:49	97	1,00	14,05	-12,85					
	14:50	98	1,00	15,00	-13,80					
	14:52	100	1,00	18,74	-17,54	18,5	7,1	-29,6	286,40	263
	14:56	104	1,00	22,92	-21,72					
	15:00	108	1,00	25,87	-24,67	18,3	7,1	-33,4	284,60	262
	15:05	113	1,00	29,25	-28,05					
	15:10	118	1,00	31,40	-30,20	18,4	7,1	-33,0	282,90	260
	15:20	128	1,00	35,35	-34,15	18,3	7,1	-31,8	281,50	259
	15:30	138	1,00	38,33	-37,13	18,1	7,1	-30,7	276,70	255
	15:40	148	1,00	41,25	-40,05	18,2	7,0	-25,6	273,50	252
	15:50	158	1,00	43,80	-42,60					
	16:00	168	1,00	45,74	-44,54	18,2	7,0	-24,5	272,00	250
	16:00	168	1,70	45,74	-44,54					
	16:01	169	1,70	46,10	-44,90					
	16:02	170	1,70	48,25	-47,05					
	16:05	173	1,70	53,15	-51,95	17,8	7,0	-24,9	271,60	250
	16:10	178	1,70	55,79	-54,59					
	16:15	183	1,70	61,11	-59,91					
	16:20	188	1,70	64,63	-63,43	17,6	7,0	-24,6	270,60	249
	16:26	194	1,70	71,60	-70,40	17,8	7,0	-23,8	271,80	250
	16:26	194	0,00	71,60	-70,40					
	16:27	195	0,00	70,60	-69,40					
	16:30	198	0,00	69,56	-68,36					
	16:32	200	0,00	68,43	-67,23					
	16:35	203	0,00	66,00	-64,80					
	16:40	208	0,00	62,00	-60,80					
	16:50	218	0,00	55,00	-53,80					
	17:00	228	0,00	49,00	-47,80					
	17:30	250	0,00	37,00	-35,80					
	18:00	280	0,00	21,15	-19,95					
	18:05	285	0,00	20,00	-18,80					
	18:10	290	0,00	18,00	-16,80					
	18:15	295	0,00	15,50	-14,30					
	18:30	310	0,00	13,00	-11,80					
	18:40	320	0,00	11,50	-10,30					
	19:00	340	0,00	8,00	-6,80					
	20:00	400	0,00	4,00	-2,80					

Q - flow rate; WL - water level, s - drawdown the water level Pump position: 79 m depth - Static Level:1.2 m

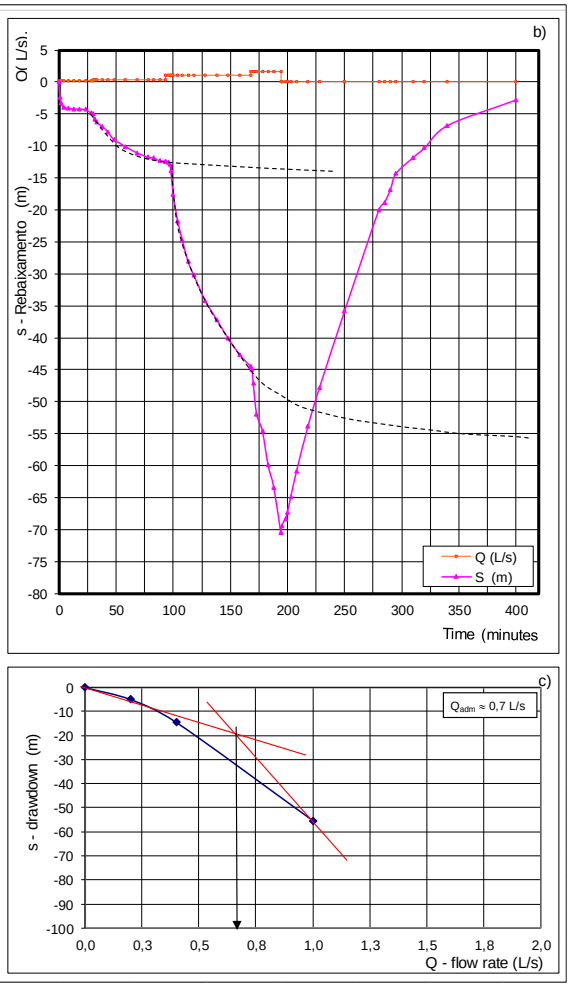

Fig. 7 Results of the final pumping test in the P1 Well at São Tiago Medical Spa: a) direct records; b) graphic evolution of flow rates and consequent drawdowns, over the time of the test; c) characteristic curve.

6. Hydrogeological Aspects

6.1 Hydrogeological Units

Considering the geological environment of the region and in particular of the basin where P1 Well is installed, considering also the other studies carried out, in particular in the abstraction, the following model is considered locally [2]:

0-2 m: unconfined or phreatic aquifer, consisting of alluviums, of medium permeability, of normal groundwater;

2-65 m: unconfined or phreatic aquifer, consisting of geological formation consisting of very altered granites, of low permeability and of the mixed type (interstitial in the most altered zone and fissural in particular in the less altered zones), with normal groundwater;

> 65 m: semi-confined aquifer, consisting of granite little altered to unaltered, with very low permeability of the fissural type, with groundwater of the special characteristics, that resurfacing in the hole in fractures that are understood to be relatively extensive.

In order to have a notion of the hydraulic characterization of the aquifer of groundwater captured by P1 Well, even if in a approximate way, the special groundwater aquifer system was admitted as continuous in the horizontal and equivalent to a porous medium, and applying the Jacob's method (in [9]), in a transitory regime, considering the characteristics of P1 Well, the following parameters were obtained, using the average of the results of the pumping test, corresponding to the lowest flow rates:

Hydraulic conductivity - K= 1.45 ×10^{-7} m/s;
Transmissivity - T = 1.1 ×10^{-6} m^2/s;
Storage coefficient - S = 3.0 × 10^{-2}.

6.2 Conceptual Hydrogeological Model

Considering the local hydrogeological situation, considering the results of field work which resulted in the geological sketch presented in Fig. 4, considering also the results of the survey of water points, namely the various types of groundwater, results in the global conceptual hydrogeological model presented in Fig. 8. The water infiltrates the highest zones and especially the urban area of Penamacor, to percolate in depth and evolve along some fractures, which occasionally may be filled with quartz and with mineralization rich in iron, and thus recharge the system deepest aquifer, and in particular the zone where P1 well was installed. In that path the groundwater acquires a special chemistry, which is the result of the water-rock interaction along the path of the various water particles. Despite the distance in a straight line, being only about 1.5 km, from the most likely recharging zone to the abstraction, the water particles will make several kilometres of path percolating along the cracks and microfissures of the massif. Some water that infiltrates north of Penamacor, in areas already in neighboring basins and initially draining in the opposite sense to the abstraction, in the direction of the schistent rocks, when bumping into them, part of the underground flow, evolves in depth and may contribute to the deeper aquifer systems. It will be a contribution to the increase of the groundwater reserves in the São Tiago Medical Spa zone.

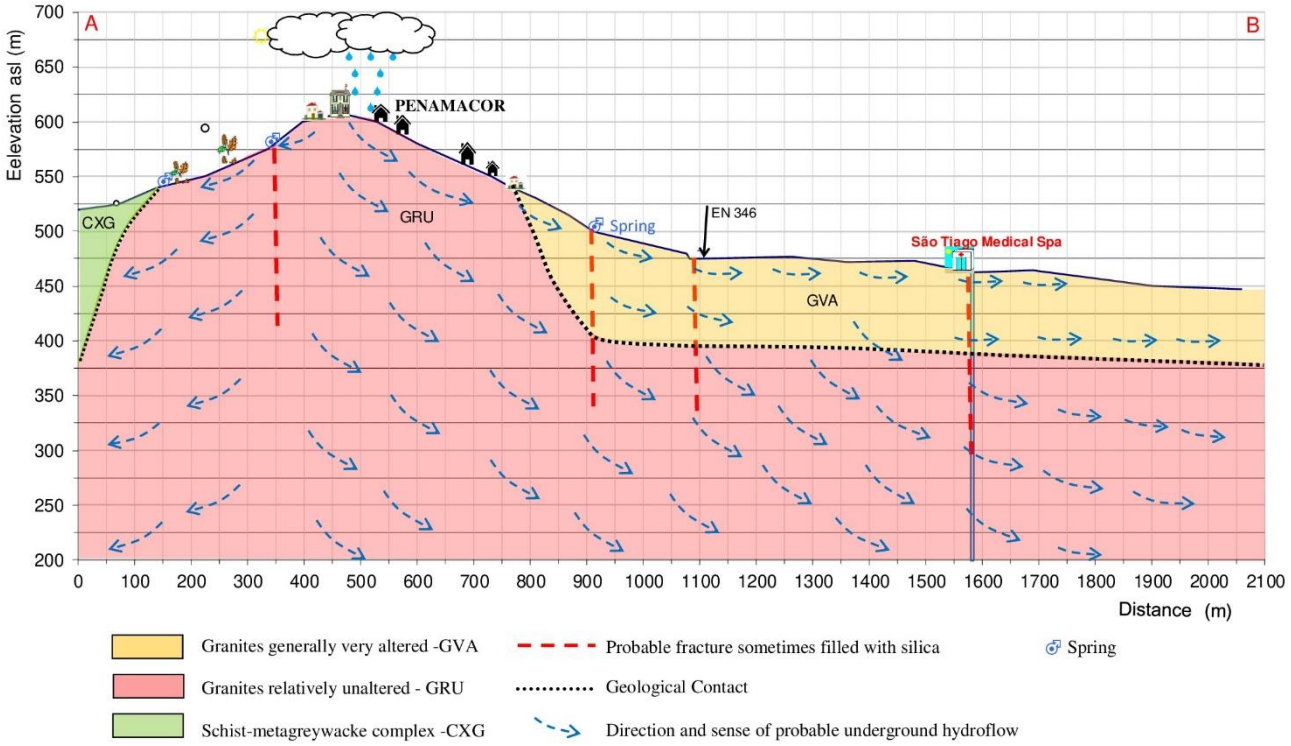

Fig. 8 Sketch of the conceptual hydrogeological model to supply the abstraction of the São Tiago Medical Spa – Penamacor. Note: the location of the AB section is shown in Fig. 4.

6.3 Groundwater Reserves

In order to have a notion, even if approximate, of the available groundwater reserve, some technical aspects are presented in this sense.

As presented in item 4, the region under study presents modest annual precipitation and consequently modest hydric superavit. On the other hand, there is a reasonable situation in terms of potential infiltration in

the recharging area due to the fact that it consists of relatively unaltered granites, with a wide range of relatively open fractures, which favour infiltration and consequently the recharging of groundwater.

From the hydrological balance there are annual hydric superavit (HS) of 382.5 L/m^2. Taking into account the characteristics of P1 Well, which is supplied by the productive fractures with extensive origin, and which is installed in a zone relatively flat, the area highlighted in Fig. 3 as the abstraction sub-basin, and surrounding areas, with a total of 3.4 km^2, are considered as a potential reloading total area. Considering the situation of surface runoff (R) and underground runoff (G), in a "G/SH" ratio of 35%, as a common situation in granitic massifs such as that of Penamacor/Monsanto granite pluton, an annual underground recharge of 455175 m^3 is obtained, which to discharge virtually in a single spring, would take a continuous flow of 14.4 L/s. However, considering that those surpluses also supply the unconfined aquifers, and that there are many surface wells in the area, it is understood that there may be availability for deep abstractions of about 20% of that flow, i.e., it is considered that there be capacity to capture in wells similar to P1 Well about 2.9 L/s. Thus, taking into account that in P1 Well the maximum allowable flow rate is 0.7 L/s, there is still a growth in production with other wells, up to the approximate value of 2.9 L/s.

7. Resource Quality

The P1 Well resource was submitted to monthly physical-chemical control at the IST Laboratory (Instituto Superior Técnico, Lisbon), between May 2014 and May 2015. Research in terms of main ions (summary physical-chemical analyses) was systematically carried out and in July 2014 the vestigiary species, gases, radiological parameters and presence of hydrocarbons and pesticides were also researched. The groundwater temperature at the head of the P1 Well is 18°C. Table 1 shows the basic statistics of the main elements and also the results of the vestigiary species. By the elements presented generically the physical-chemical stability is very good, since the global parameters and main ions, almost in the whole, present relative standard deviation ($SD_{Relative}$) less than 10%, with the exception of Iron with 11.8%.

On the other hand, a detailed observation of the graphical evolution of the results of the various chemical elements, over time, shows that there is no global trend throughout the year, as exemplified in the case of total mineralization in Fig. 9a. It is evident that groundwater in relative terms is very rich in silica in non-ionized form (Table 1, Fig. 9b) with about 24% of total mineralization, and in relation to the main ions (Fig. 9c) bicarbonate and sodium as anion and cation, respectively, are the more representative, with the particularity of calcium and magnesium having much significance. Thus, in ionic terms, the groundwater under study is called sodium-calcium-magnesium bicarbonate.

Still, in relation to other classifications, it is a weakly mineralized water (in relation to total mineralization), silicate, with acid to soft reaction, and still hypothermal (temperature below 25°C).

In relation to the vestigiary species, there is a very significant occurrence of Mn with 540 μg/L and then Sr and As with 39 and 35 μg/L, respectively, and other elements with traces (< 8 μg/L), which according to their content, from highest to lowest, are the following: Mn> Sr> As> Rb> I> Al> Cs> Nb> U.

In relation to gases and radiological parameters, the unique results are presented when the complete physical-chemical analysis was performed. Gases: Free CO_2 = 42 mg/L, Radon (Rn) = 105 Bq/L, Sulphidric Acid (H_2S) < 0.50 mg/L and Dissolved Oxygen (O_2) < 1.0 mg/L. Radiological parameters: Total Alpha = 0.118 Bq/L, Total Beta = 0.220 Bq/L.

On the research of aromatic hydrocarbons and pesticides it is noted that they were not detected in groundwater.

About the monthly microbiological control, carried out by the Public Health Laboratory of Guarda, in the

same period of the physical-chemical control, it is pointed out that none of the analyses carried out gave improper results, orienting to a groundwater suitable for classification as natural mineral water.

After the studies previously presented, the notion was consolidated that there were conditions to move forward with the launch of a new medical spa, as the quality of the resource proved to be stable and microbiologically adequate.

In order to collaborate with the next step, the medical-hydrological study, under the responsibility of a doctor, to investigate the therapeutic applications, a comparison was made with the chemistry of other established Portuguese natural mineral waters (Fig. 10), namely the sulphurous waters, the silicates and also the water from the Vale da Mó because it have iron and magnesian.

A detailed analysis leads to say that the water profile of P1 Well, is not similar to any other existing in the country. This situation, if on the one hand hinders the scenario of potential applications, on the other hand, is very interesting, because it opens the prospect of bringing something new to the activity of the Portuguese medical spas.

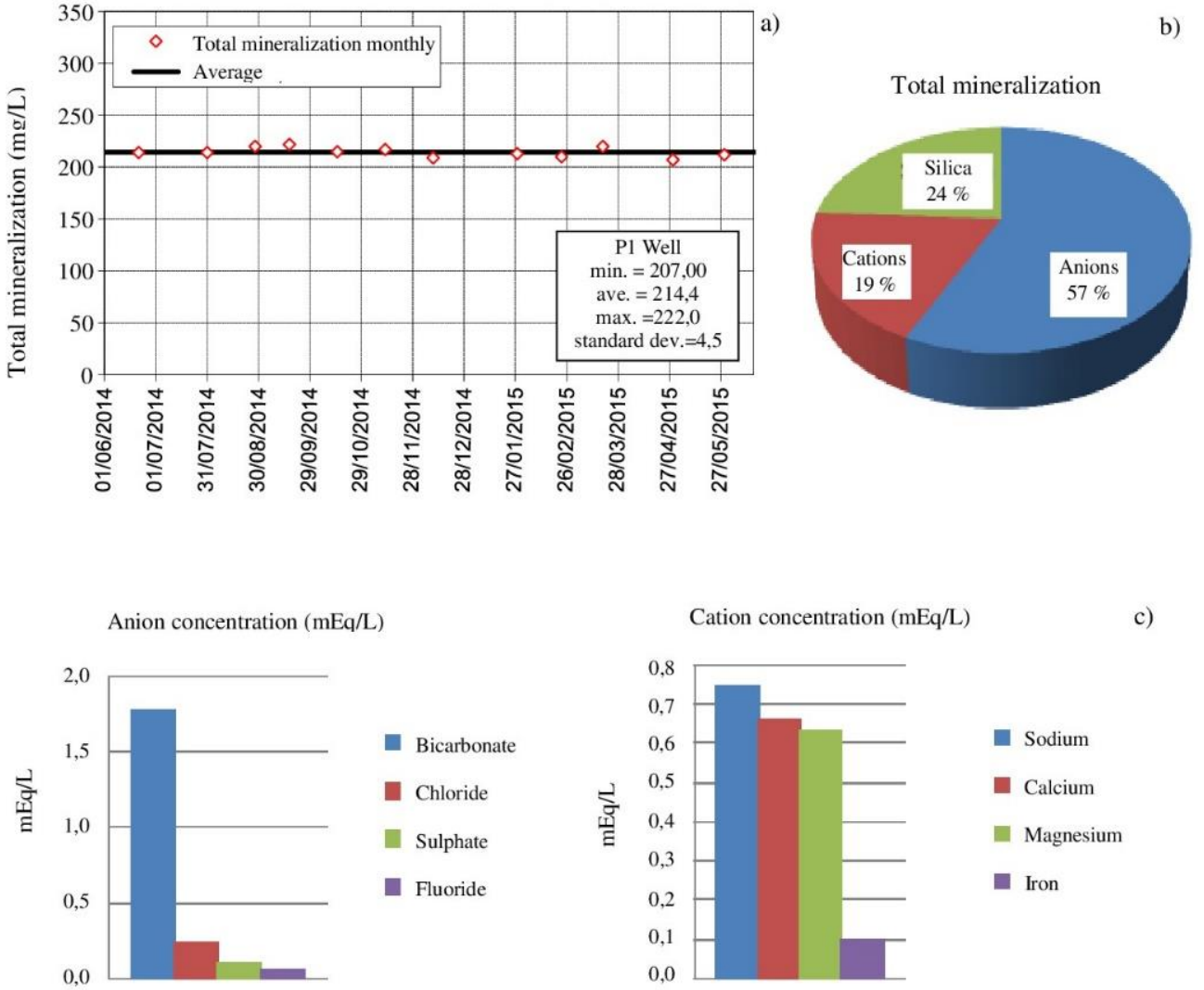

Fig. 9 Results of physic-chemical analysis of groundwater from P1 Well, in terms of: a) total mineralization over the year, b) distribution of total mineralization in terms of ions and silica in non-ionized form, c) distribution of main ions.

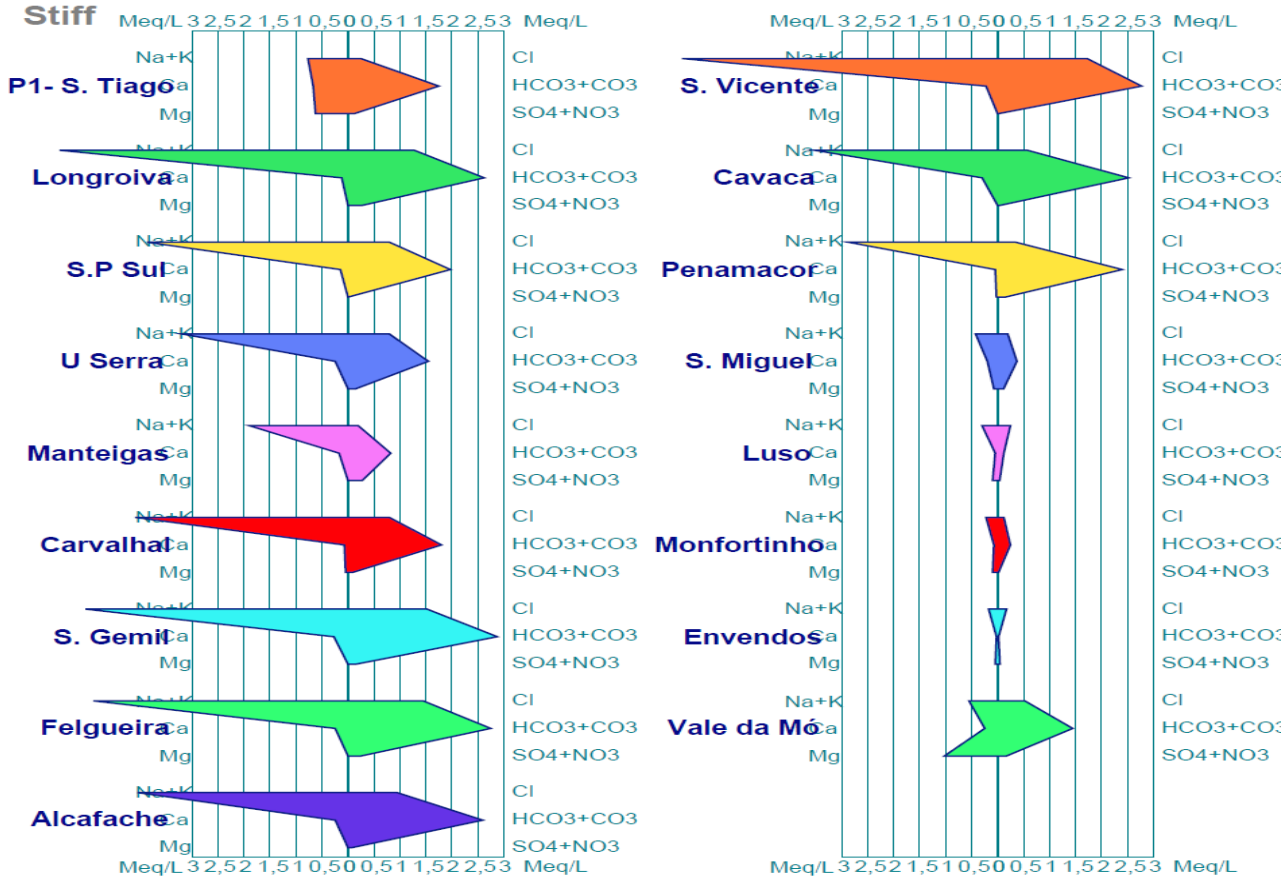

Fig. 10 Comparison of the groundwater chemism under study (from P1 Well), with other Portuguese natural mineral waters, in a Stiff diagram.

8. Final Notes

Based on the results of the previous elements, presented in an unpublished technical report, well developed, presented in 2015 [2], it was proposed to the Portuguese State, through the Directorate General for Energy and Geology (DGEG), the licensing of a new natural mineral water, following the legislative guidance of line d) of point 2 of Art. 16 of the Decree - Law 86/90, of 16 March [3], having been accepted, with the signing of the Concession Contract in 2016/02/05 between the Portuguese State and the proposing Concessionaire (Malcatur), whose extract from it, was published in the official publication "Diário da República" of 24 February 2016 [10].

In the follow-up, a medical-hydrological study was conducted, led by a doctor, who, in temporary facilities, submitted a sample of patients, having proved the benefit of the groundwater under study for rheumatic, musculoskeletal, and respiratory diseases, and these therapeutic indications were published in the "Diário da República" of 4 September 2017 [11].

In view of the foregoing elements, the Portuguese State, demanded the construction of a definitive Bathhouse, to serve as a Medical Spa, and forced the approval of the "Exploration Plan", based on a technical report, on the extraction processes of the resource, adduction-distribution, among others [12], in addition to the imposition of establishing the Protection Perimeter, also proposed in 2017 [13], and still awaiting superior approval and respective publication in the Official Publication (Diário da Républica).

So, finally, it is emphasized that Portugal currently offers a new Medical Spa, in association with a new Hotel [14], and that it will have a lasting future, if among many others, above all preserve the quality of

the resource (natural mineral water), and for that it is absolutely essential to implement monitoring systems, namely for flow rate control to be extracted in the abstraction, consequent piezometric levels, quality of the resource, in addition to the need to impose appropriate restrictions in relation to activities and occupation of the territory, inside protection perimeter zones.

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The author thanks C.M. de Penamacor and the Grupo de Desenvolvimento de Termas de Portugal (Malcatur's representative), for the financing of the field work and also FCT - Foundation for Science and Technology, I.P. within the GeoBioTec Research Unit - UID/GEO/04035/20, for the support granted.

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Integrated Management of Facades by Means of a Real-Time Automation System

Carlos Gilberto Guillermo Ramírez
Madrid BIM User Group "guBIMad", Spain

Abstract: Can a BIM Manager be a fundamental piece in the economic development of a country? Can he reduce greenhouse gas (CO_2) emissions in real time? This research work aims to demonstrate that it is possible. Spain produces 330 million tons of CO_2/year. The government has committed to lowering them by 20% by 2030. Building is a sector with a huge impact on CO_2 emissions. The concern of owners or tenants of buildings lies in controlling or reducing operational costs. Office buildings consume two thirds of the total energy consumed, where facilities in general account for 90% of total expenditure. This research is divided into three stages: the first is to find the climatological conditions of the project site, to establish the incidence of the sun with the envelope of the building, the coefficient of thermal transfer and a family of adaptive component. Then, an analysis of each room of the building (temperature, occupation, ventilation, etc.) is done. Finally, the temperature of each room in real time is monitored. The integrated management of facades by means of a real-time automation system can be a useful tool in the control of CO_2 emissions.

Key words: asset management, smart facades, CO_2 emissions, continuous improvement, facility, monitoring, rehabilitation

1. Introduction

A BIM manager should be responsible for managing the information of a building, both in pre-construction models and in already built projects. He or she has a key role in decision making, comparing real data, construction costs and building impact. He must participate in the entire process: from the initial design team (BIP, CDE, BEP, etc...), to its projection, as well as in the monitoring of the building, since together with the Energy Manager, he establishes the consumption in real time, historical data, reports of evolution and deviation from the pre-established.

Building is a sector with an enormous impact on the evolution of energy consumption and CO_2 emissions. In the European Union as a whole, buildings are responsible for 40% of final energy consumption and 36% of carbon dioxide emissions. In Spain, housing and tertiary sector buildings account for 26% of total energy consumption, 17% and 9% respectively [1].

There is now a broad consensus on the strategic importance of buildings in achieving the Community's energy efficiency and greenhouse gas emission reduction objectives. The construction of new buildings with design and energy efficiency requirements that are much more demanding than the current ones and that demand little or no energy — buildings with almost zero or no energy consumption — will be an obligation for EU countries from 31 December 2020 [1].

On the other hand, the increase in energy costs has been the main driver of growth in BAS (Building automation system) systems, supported by the benefits of controlling with a comfortable and safe environment in commercial and office buildings, which are reflected in significant reductions in operating costs, greater security and performance of users.

This research work is divided into three parts: the first part is done from the outside and consists of

Corresponding author: Carlos Gilberto Guillermo Ramírez, Architec; research area/interest: energy sustainability. E-mail: guilcarlos@gmail.com.

finding the climatic conditions of the project site; the second part is done inside each room, enclosure or space of the building, determining the air conditioning systems used and establishing the thermal comfort conditions for the users; and the third part is a real time monitoring, for which we will use the integration of the BAS systems with programming tools.

The aim is to incorporate intelligent, properly distributed controllers that operate independently, but are supervised by central software that allows the building's energy consumption to be controlled in real time.

2. Theoretical Framework

Greenhouse gas emissions in Spain shot up by 4.4% in 2017. This is the largest year-on-year increase since 2002. Currently we produce 334 million tons of CO_2, the government has committed to reach the year 2030 with 20% less emissions compared to 1990. This implies a reduction of more than 100 million tons less [2].

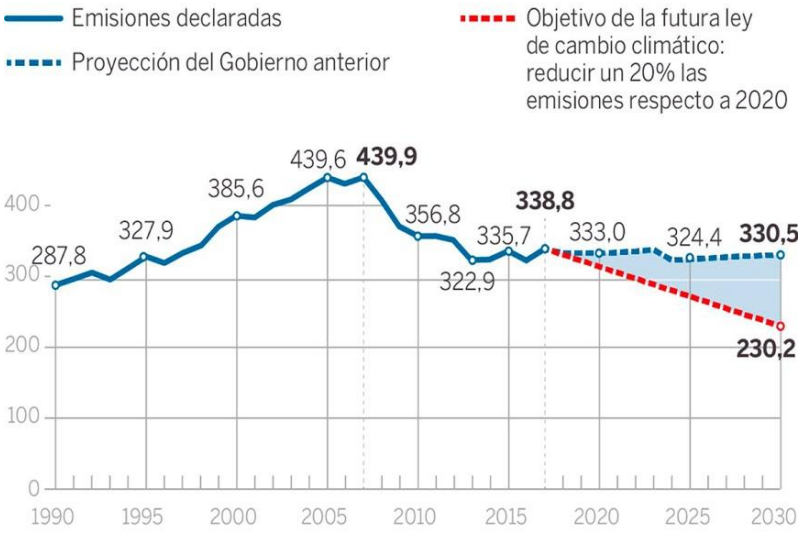

Fig. 1 Evolution of greenhouse gas emissions in Spain (Source: Ministry of Ecological Transition, 2018).

In addition, the constant concern of building owners or tenants is to control or reduce operational costs. Commercial office buildings consume more energy than any other commercial building because two-thirds of the total energy consumed is electricity, with lighting, office equipment and HVAC accounting for 90% of total expense.

WWF argues that the only truly effective formula for reducing emissions and energy consumption in the building sector is through reducing the energy demand of the existing building stock by improving the insulation levels of buildings.

In recent years, Spain has introduced various policies and regulations aimed at improving the energy performance of the building sector.

- CTE. Technical Building Code 2006
- Regulations for thermal installations in buildings 2007
- Energy certification for new buildings. 2007
- State housing and rehabilitation plan. 2009-2012
- Energy saving and efficiency plan. 2008-2012 (PAEE+)

Mainly the aids offered by the latter are oriented to the renewal of thermal equipment.

In 2009, refurbishment accounted for only 19% of total construction investment in Spain compared to the EU average of 43%.

BAS systems consist of direct digital control (DDC) to provide lower operating costs and ease of operation. PID controllers (a simultaneous feedback control mechanism widely used in industrial control systems), microprocessors monitor and adjust building systems

to optimize their performance and performance with other systems in order to minimize the total power and fuel consumption of the facility [1].

3. Methodology

3.1 Softwares

Revit
Dynamo
Phyton

3.2 Method

3.2.1 First Phase

The starting point was a model with detailed construction elements, on which an analysis of the energy configuration was carried out: using REVIT the project parameters were established before the simulation was carried out. From the Analyze tab, the heating and cooling loads option was selected and the general parameters were determined: building typology, project location, phase, envelope, etc.

The geo-location data provided by REVIT were used, using the sun configuration tool. The activation or not of the option Use summer time was taken into account, for those zones where differentiated timetables are used by winter or summer, as was the case of this project.

As for the weather, the Use nearest weather station option was activated. In this way, the program collected the updated weather data of the area.

Subsequently and using of the SunSetting. Current Date Time mode, the information obtained from REVIT was incorporated into the virtual prototype of DYNAMO and the normal solar rays were determined, showing those that could impact on the façade. Then by the placement of coloured filters the area most affected by solar radiaton was identified, according to the time, day, month or year to be studied, in this particular case 24th May 2019, at 10 am.

Model with Dynamo: The workflow will be: definition of levels, creation of building skin and finally definition of an adaptive component family.

Building level definition: With DYNAMO you make an algorithmic tree where you define the levels with an Integer slider; then the height between floors with a Number slider, with the node of Level. Byelevation And Name, to give the name you want to each level. In this way, the 40 levels and the height between floors of 3.50 m are defined.

Definition of the building skin: To create the shape, three circumferences were established, and the skin building structure was defined. We choose the location of circumferences: first one, the base, second one 60% of the height of the building (this is an arbitrary measure), and the last one, level 40 of the building. The next step, using a loft, we connected the three circles and create the building's skin.

Definition of an adaptive component family: To finish with the building volume, an adaptive component family was created in REVIT. It was an adaptation of the curtain wall panel pattern based. This family allows repeating systems generated by a matrix. The idea is to create a family divided into two parts: one part will be solid with a tolerance of up to 99% with respect to the transparent part, and the other part will also be transparent, with a tolerance of up to 99% with respect to the solid part. The purpose is to control the solar radiation inside each room of the building, through an automatic passive system. In DYNAMO, this newly created family was adapted to the skin, through an Adaptive Component. By Point node. In this way, a volume with a tolerance in the family of 50% opacity was obtained, with 50% transparency.

3.2.2 Second Phase

In this model, a temperature probe (DS18b20), connected to a computer board (SBC), RASPBERRY Pi, was used a PHYTON compatible computer, a programming language that is also compatible with DYNAMO. The objective was to have a real reading, subjecting the temperature probe to different hot and cold conditions, generating a real time reading of what temperature we have, depending on the atmospheric conditions of the exterior, described in the first phase.

Although in a real project, the measurement of the internal conditions changes with the level of occupation of the room, the activity of the user, the type of use of the room, ventilation, air conditioning and humidity; for the model from which we started, not all these factors were taken into account.

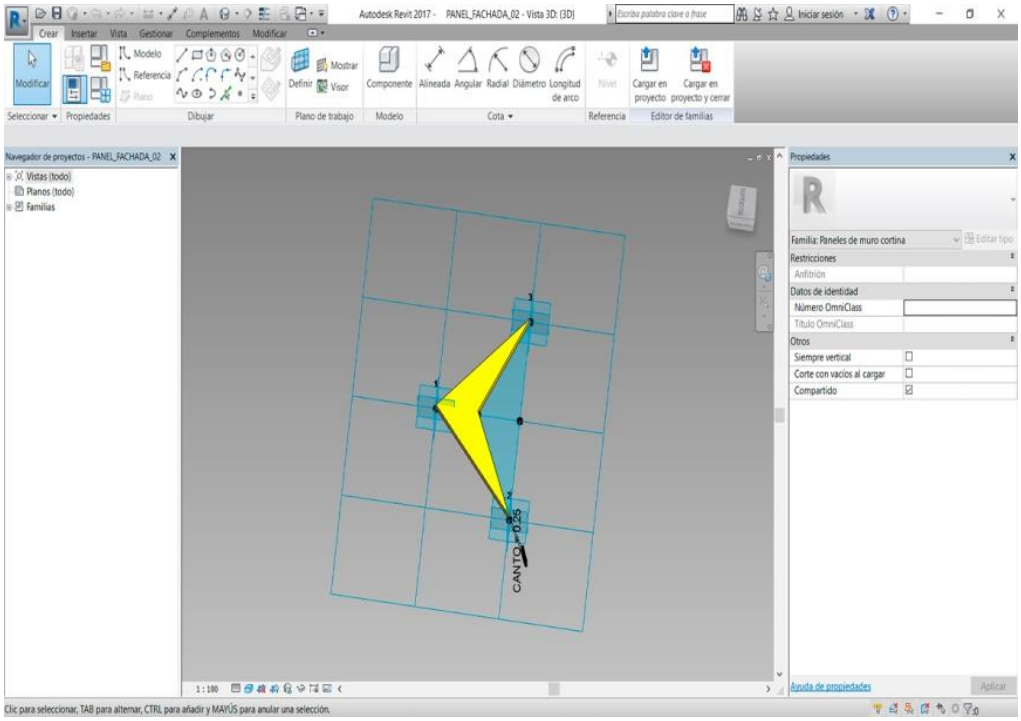

Fig. 2 Adaptive component family.

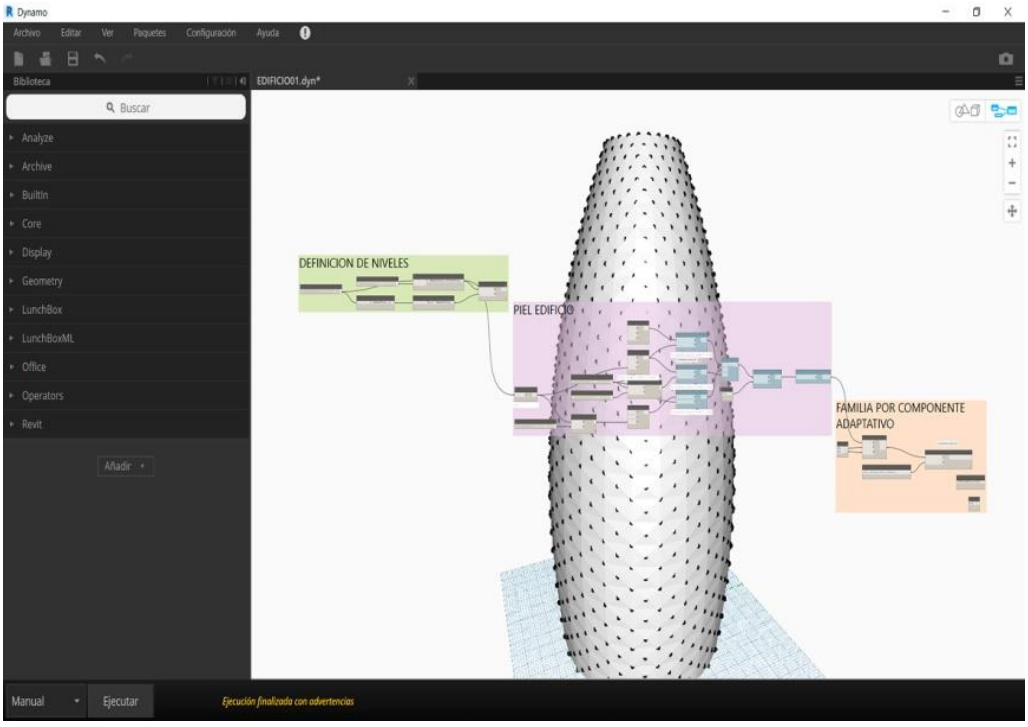

Fig. 3 Prototype made in DYNAMO.

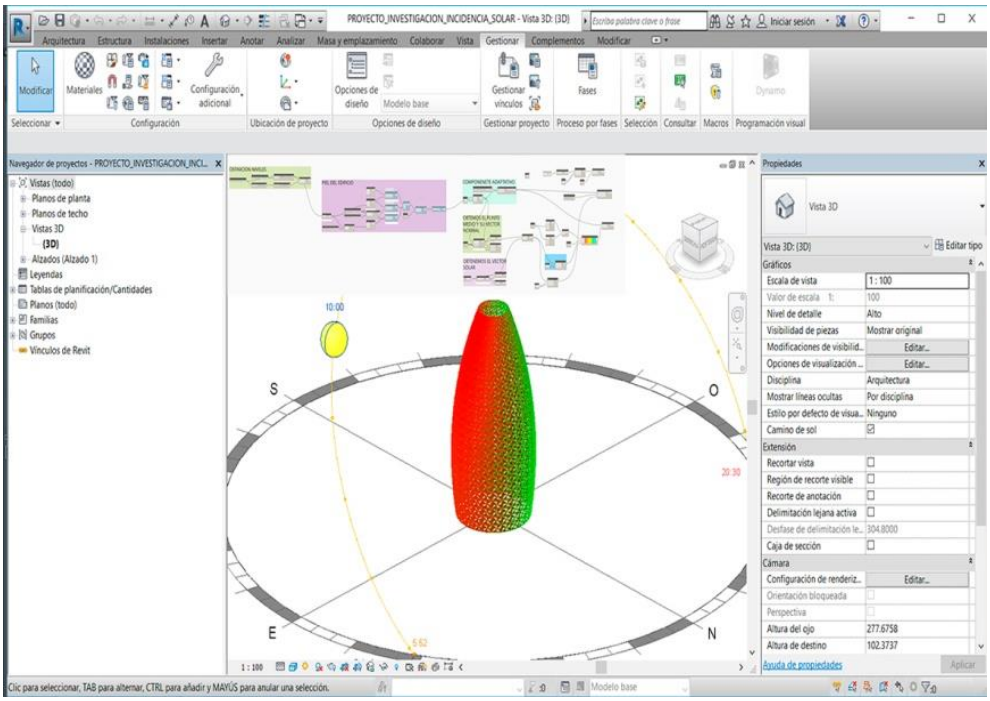

Fig. 4 Incidence of normal sun on prototype façade.

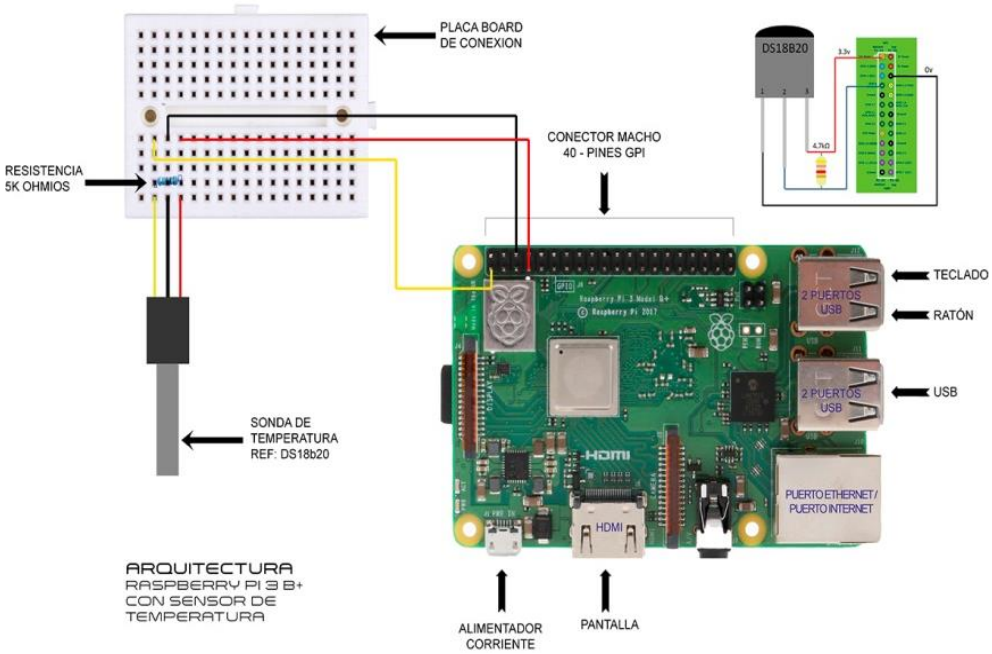

Fig. 5 Raspberry Pi 3B plus connection architecture with temperature sensor.

3.2.3 Third Phase

The following materials will be used:

- A RASPBERRY Pi 3 B+.
- Temperature Sensor DS18b20.
- Resistance of 5 K ohms.
- A BOARD plate.
- Three jumper cables, female and male.
- Internet connection.
- Keyboard.
- Mouse.
- Display with HDMI cable.

First the temperature sensor is connected to the BOARD, then the jumper cables are connected, paying attention to the ground cable, matching the middle cable of the temperature sensor; a resistance of 5 K Ohm was placed on the BOARD. This resistor connects the right-hand pin to the middle pin. This is called a pull-out resistor and is used to ensure that the middle pin is always on. Then the keyboard, mouse, HDMI and power supply were connected to the RASPBERRY Pi and started from the desktop.

RASPBERRY Pi configuration: Two steps are required to enable the Temperature probe.

Install PYTHON library: First you must install a PYTHON library, previously written code that allows the PYTHON code this will allow us to communicate with the temperature sensor. The library is called w1thermsensor. To install it, we need to use the Terminal. You can find the terminal icon on the top left of the screen.

When the terminal opens, enter the following to install the library, simply press ENTER to begin.

```
sudo pip3 install w1thermsensor
```

This is how you have the PYTHON library. Close the terminal window.

Interface: The DS18b20 uses a 1-wire serial interface, this is the center pin of the sensor, which is connected to the RASPBERRY PI via the black wire in the diagram. To communicate the RASPBERRY PI with this pin and use the RASPBERRY PI configuration tool, found in the Preferences menu. When it opens, click the Interfaces tab, and then click Enable for 1-Wire interface. Now click OK and you will be prompted to restart, upon acceptance, you will let RASPBERRY PI restart on the desktop.

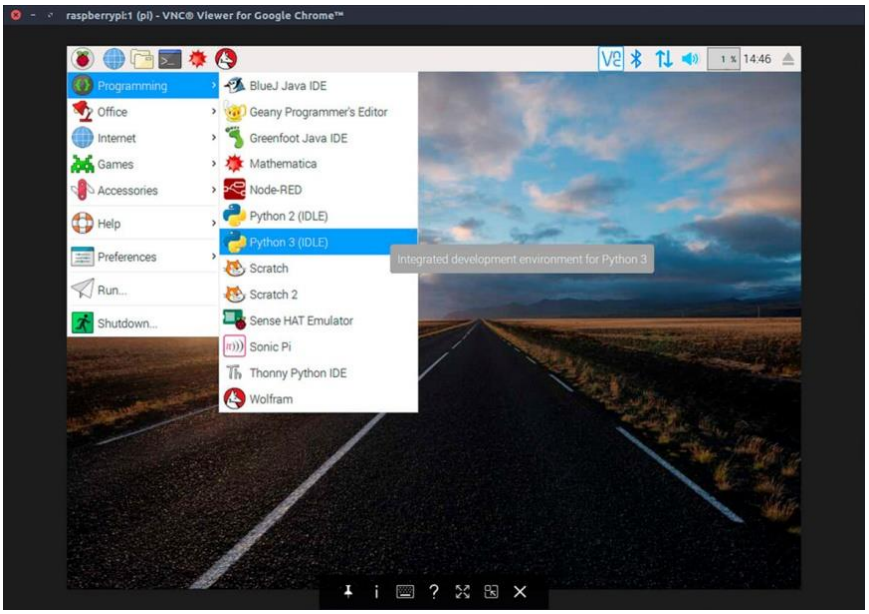

Fig. 6 VCN-raspberry Pi interface.

Writing the python code: This project will collect the temperature of the DS18b20 sensor every second or every given interval (here, for example, with intervals of every second), and print it on the screen. The code will be executed forever.

To write the code we will use the PYTHON 3 Editor found in the Programming menu.

When the application opens, click File >> New to create a new blank document. In this new window, click File >> Save and call the project temperature-sensor.py.

The first step in any PYTHON project that uses libraries is to import the libraries you want to use. In this case, time is imported to control how often the

sensor data is collected, and w1thermsensor is imported to allow the project to communicate with the sensor.

```
import time
from w1thermsensor import W1ThermSensor
```

Sensor: An object must be created to store a sensor connection. Then, instead of writing W1ThermSensor ( ) every time you want to use the sensor, you will store the connection in an object called sensor.

```
sensor = W1ThermSensor()
```

To get the data from the temperature sensor every second and run it forever, a True loop is used to execute the code inside it forever.

```
while True:
```

In the loop, the first thing you have to do is get the current temperature from the DS18B20 sensor and then store it in a variable called temperature. The variables are boxes/containers in which you can store any data.

```
temperature = sensor.get_temperature()
```

Having the data, it is printed on the screen using the print function. But the data is used in the form of a sentence that determines what the temperature is in degrees Celsius. For this, a Python trick called string format is used: we use a%s that will format the temperature data from a float (a number with a decimal place), to a string (text, characters that can be printed but not used in any mathematical equation).

```
Print ("The temperature is %s grados" % temperature)
```

The last line of the PYTHON code will tell the RASPBERRY PI to wait 1 second between a temperature reading.

```
time.sleep [1]
```

Full Code Listing: The code should approximately match this one:

```
import time
from w1thermsensor import W1ThermSensor
sensor = W1ThermSensor()
while True:
    temperature = sensor.get_temperature()
    print ("The temperature is %s grados" % temperature)
     time.sleep [1]
```

Finally it is given to save in PYTHON and then execute.

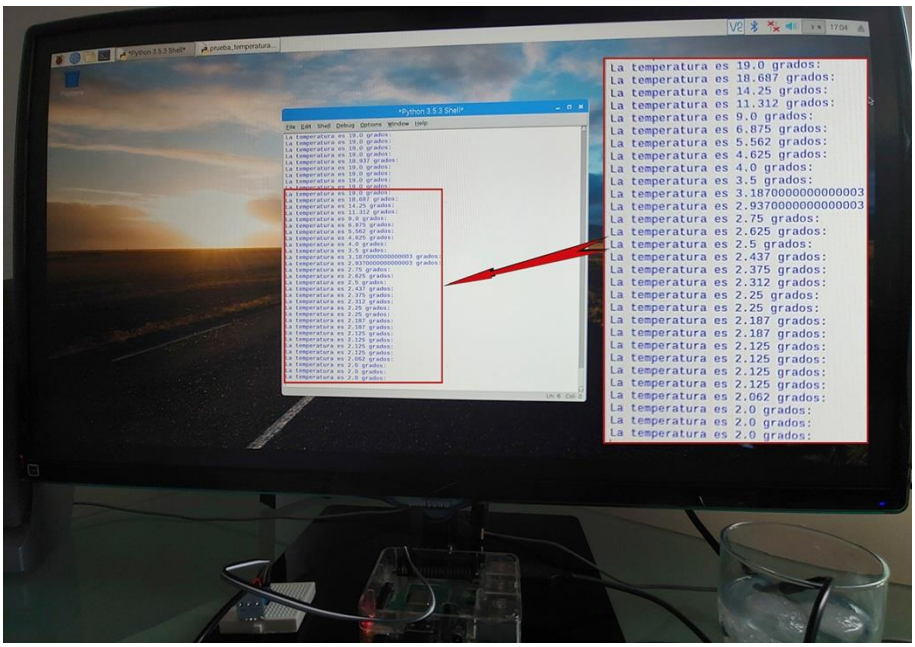

Fig. 7 Real-time results at one second intervals (cold).

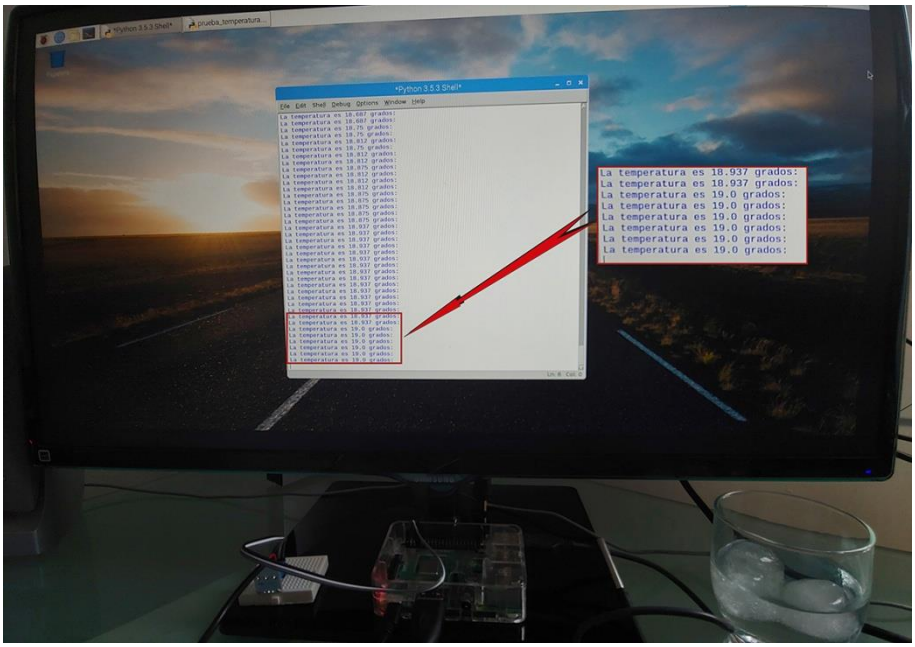

Fig. 8 Real-time results at one second intervals (heat).

4. Discussion.

The BIM methodology allows us to anticipate possible problems that will be generated in the building. The objective of this research was to generate a thermal comfort solution for the users of a building, without increasing the production of CO_2 and reducing construction and maintenance costs of the asset.

The initial model chosen for this research was a virtual prototype, but the field of use of this technology aims to cover either a model in its initial stages of design (conceptual masses), or a model with detailed construction elements. In a real model, an analysis of the composition of the layers of the building envelope must be included in the first phase, in order to find the thermal process coefficient, which has not been done in this model.

One of the contributions of this project is the analysis in the pre-construction phase of the thermal conditions, both internal and external, that will affect the building in real time, determining them from the initial phases of design.

For the first phase, the model could also be made with REVIT, where the volume of the building is made with a mass per revolution and through which a non-parametric prototype volume is obtained. However, REVIT is not compatible with PHYTON. One of the limitations of this study, is that for the time being it can only be used for modeling software.

In this research, it has been decided to use DYNAMO, since through the automation of the algorithmic trees and the compatibility with the PHYTON programming language, it simplifies and concretizes the process of temperature reading in determined time ranges, which will be the condition for the modification of the facade and the air conditioning systems.

Nevertheless, the main difficulty that has been presented in this study, is to obtain the suitable communication between DYNAMO and PHYTON, since it is the newest and latest computer science language used, and it is an area of knowledge that is not handled frequently in architecture, so the diffusion of its implementation, implies a specific formation on the part of the professional to whom it concerns.

The strategy to extrapolate the results of this research is the use of BAS (Building Automation Systems), which integrate different types of disciplines, for an easier and more exhaustive control of the systematizations, with lower costs.

In a search for publications, some facility works [10-12] are found, with integration of the IoT (Internet of things) and BIM systems. The most suggestive is the one by Kai-Ming et al, in which sensor data are visualized in BIM in different scenarios of the same enclosure, in order to make complex decisions in facility, integrating multidisciplinary information.

This project aims to create a line of research to take advantage of the integration of programming disciplines with BIM information. Future studies aim to integrate, for example, variables such as air humidity, which can also have an impact on the management of building installations.

5. Conclusions

The contribution of parametric models or virtual prototypes, in terms of being able to establish or create parameters in a collaborative way, with all those who act in the realization of a project, and the connection with programming languages, opens many possibilities to obtain true and accurate information on consumption, evolution, cost control, CO_2 production, etc. This connection will make this whole process more predictable, avoiding economic deviations due to bad decisions in pre-construction and construction phases, and/or to cost increases during the building's life cycle.

The compatibility of visual scripting programs that allow the creation of personalized algorithms with programming languages, together with current building information modeling software, can be a promising tool for the optimization of building processes.

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Electrocoagulation: Clarification of Residual Water From Chemistry Laboratories

Iago dos Santos Soares, Cleilson do Nascimento Souza, Libertalamar Bilhalva Saraiva, and Ana Mena Barreto Bastos

Institudo Federal de educação ciência e tecnologia do Amazonas, Brazil

Abstract: This paper adresses the application of the electrochemical method to the treatment of chemical residues in the analysis and research laboratories in the areas of chemistry at Instituto Federal de Educação, Ciência e Tecnologia do Amazonas — IFAM, whose main objective was the removal of pollutants without adding chemicals. The acrylic reactor with a capacity of 40 L was divided into three tanks of 0.29 m high by 0.20 m long and 0.262 m wide (15.2 L per unit), with a ½ in. pipe for the waste inlet and outlet of treated water. The residues from the laboratory of physicochemical analysis — called residues 1, 2 and 3 — were characterized with analyzes of pH, conductivity, turbidity, alkalinity, COD and solids. The electrochemical cell was assembled with monopolar electrodes in parallel with an arrangement of 2 pairs of honeycomb electrodes, using a solid aluminum plate with a thickness of 3 mm and 200 mm high by 200 mm long, cut in one corner of each plate diagonally in order to place the fixing screw, with 400 cm² submerged in the residue. The direct current source was "Fonte de Alimentação ICEL Manaus PS-3005", with output voltage from 0 to 32 Volts, amp from 0 to 5A, input voltage of 110-220 Volts, without polarity inversion. Currents from 3A to 5A were used, depending on the chemical properties of the residue, with a reaction rate of 2 to 4 hours. The plates (sacrifice electrodes) were weighed before and after the electrocoagulation/flocculation with a 5.7g mass loss. The pH and alkalinity showed an increase after the reaction for all residues, with a decrease in turbidity and color. The washout of the pollutant varied according to the increase in pH and the compounds formed with $Al(OH)_3$. In view of the results obtained in the experiments and analyzing the acceptable limits for legal disposal, issued by CONAMA Resolution 403/2011, it can be inferred that the system is efficient and removes most of the dissolved or suspended substances from the liquid effluents of the teaching and research laboratories.

Key words: residues from the IFAM chemical laboratory, electrocoagulation system

1. Introduction

The generation of chemical residues in the analysis and research laboratories in the areas of chemistry and biology is quantitatively lower when compared to large industries in the same field, such as chemicals and petrochemicals. The big problem with this form of generation is the varied and inconsistent composition of residues, as they constantly change and it is difficult to find a standard and effective method for their treatment.

Corresponding author: Libertalamar Bilhalva Saraiva, Ph.D.; research areas: Environmental Engineering and Chemistry, development of treatment and mitigation processes, mainly in industrial effluents Advanced treatments like biodegradation of phenols by fungi. E-mail: libertalamar.saraiva@ifam.edu.br.

In techniques based on electrochemistry, in which coagulation reactions take place inside a reactor with metallic electrodes, resulting in the dissolution of this metal with the generation of ions and gases (hydrogen and oxygen), the contaminants present in the residual water stream are treated both by chemical reactions and precipitation or physical and chemical bonding to colloidal materials that are being generated by the erosion of the electrode. They are then removed by electroflotation, or sedimentation and filtration.

The electrocoagulation process is used in various industrial effluents to remove chemical and food waste and sanitary sewage. According to Theodoro, 2010, "it is a versatile technique with easy operation and no cost with chemical reagents, it appears as an alternative to

carry out oxidation and not only transfer the phase of interest, but to aggregate the particles in the solution in an aqueous medium for removal of the pollutant by electroflotation".

Khandegar and Saroha, 2013, point out the main advantages of electrocoagulation in relation to conventional chemical coagulation: no need to add chemicals and better removal capacity for the same species, startup time is minimal, less sludge production and consequently lower costs to dispose of this material, in addition, the generated sludge is more easily filterable and can be used as an additive for the soil. However, the technique also has some limitations, such as the need to periodically replace the sacrificial anodes, requires minimal conductivity of the solution, the possibility of forming an impermeable oxide film on the cathode that can cause resistance to the flow of electric current and also the high cost of electricity, which can result in an increase in the operational cost of EC [1].

The work was developed for the residues of the chemical laboratories, mainly the physical-chemical laboratory, where the flow of analyzes and experiments is greater and had as main objective to clarify the liquid effluents of the laboratories by removing color and turbidity first with the consequent removal of the main pollutant compounds in a simple batch, by electrocoagulation/electrofloculation.

2. Methodology

The project was developed at IFAM-CMC, with the following steps: assembly of the electrochemical reactor, characterization of the effluents from the DQA/IFAM/CMC physicochemical laboratories, reaction in the batch reactor, analyzes of the reactor effluent.

2.1 Assembly of the Electrochemical Reactor

The acrylic reactor with a capacity of 40 L was divided into three tanks of 0.29 m high by 0.20 m long and 0.262 m wide (15.2 L per unit), with a ½ in. pipe for the waste inlet and outlet of treated water, Fig. 1, with the aim of treating residues from different laboratories simultaneously.

The electrochemical cell was assembled with monopolar electrodes in parallel with an arrangement of 2 pairs of honeycomb electrodes, using a solid aluminum plate with a thickness of 3 mm and 200 mm high by 200 mm long, cut in one corner of each plate diagonally in order to place the fixing screw. In the center the plates are drilled with a 10 mm hole for fixing a central PVC screw. The distance between the electrodes was 30 mm, Fig. 2.

The direct current source was "Fonte de Alimentação ICEL Manaus PS – 3005", with output voltage from 0 to 32 Volts, amp from 0 to 5A, input voltage of 110-220 Volts, without polarity inversion.

2.2 Characterization of the Effluents of the Physical Chemistry Laboratories of DQA/IFAM/CMC

The residues from the practical classes in the

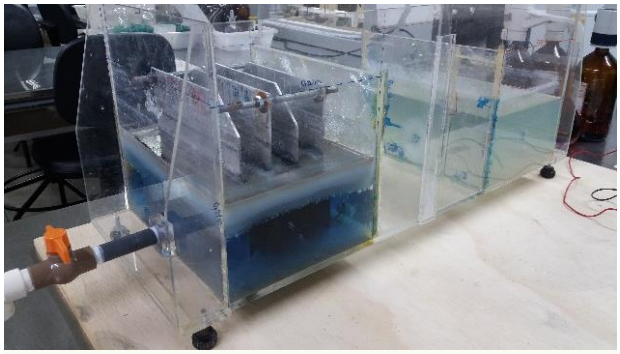

Fig. 1 Acrylic reactor with the electrochemical cell in the first tank.

Fig. 2 Assembly of the electrode plates of the electrochemical reactor tank.

physico-chemical and analytical laboratory were collected and separated into four types of residues. They were stored in 20 L barrels, generating an approximate total volume of 80 L of chemical residues, with distinct characteristics of color, pH, turbidity and conductivity.

In order to better characterize the residues, a mapping of the various analytical procedures that generate liquid residues was carried out by analyzing the scripts of the practical classes in the chemistry laboratories. It specifies the chemical composition of the effluent.

Several authors have observed that the pH, color, turbidity and conductivity of the affluent to the electroflotation reactor is an important operational factor that influences the performance of the electrochemical process [2].

Table 1 shows the four types of residues collected on different dates and practical classes and therefore characterizes the chemical compositions. Residue 1 has a variety of alkali metal and alkaline earth metals salts, transition metals, organic and inorganic acids. Residue 2 has transition metal salts, such as sulphate and nitrate salts, inorganic acids, as well as a cobalt complex. Residues 3 and 4 are similar, but there is a lesser diversity of salts and the presence of nickel salts in the residue.

The identified residues were submitted to analytical methodologies based on the Standard Methods of Water and Wastewater [3]. The parameters analyzed were pH, turbidity, conductivity, chemical oxygen demand (COD), alkalinity, chlorides.

2.3 Electrocoagulation Reaction in the Batch Reactor

The residues were subjected to the electrocoagulation and electroflocculation process in a batch electrochemical reactor with currents of 3 to 5 A, time of 2 to 4 h, with polarity inversion every 30 minutes.

Electrocoagulation transformed the impurities into "solid" flakes, forming two distinct phases: treated liquid effluent and solid residue (treatment sludge), separated by flotation/sedimentation and filtration. The liquid effluent was subjected to the same analytical methodologies by which the initial residue was analyzed, and the solid residue was separated, dried and later evaluated for the reuse of salts, insoluble metal hydroxides and later stored and or discarded.

Table 1 Chemical composition of liquid residues from the physico-chemical and analytical laboratories.

Residues	Chemical composition of practical classes: Analytical and inorganic chemistry
1	Acetic acid 1 mol/L, NaOH 1 mol/L Phenolphthalein and methylorange indicators, Bromocresol green Alkaline earth metals Determination of H_2O_2 Copper Salts. $BaCl_2$, $CaCO_3$ $AgNO_3$; 0.101 mol/L, NaCl, $K_2Cr_2O_7$, H_2SO_4, 0.1 mol/LHCl $AgNO_3$; 0.1012 mol/L, NaCl, $K_2Cr_2O_7$, 1 mol/L H_2SO_4, 1mol/L HCl
2	H_2SO_4. Ag_2SO_4 $CuSO_4$ $Cu(NO_3)_2$ HCl, HNO_3, Hg $(NO_3)_2$ $CuSO_4.5H_2O$, Soybean oil Cobalt Complex $[Co(NH_3)_5$ CNO]Cl $K_2Cr_2O_7$, K_2CrO_4 $FeCl_3$
3	Acetic acid 1 mol/L, HCl mol/L Sodium chloride NaCl 1 mol/L HCl 1.0 mol/L, H_3PO_4 1 mol/L H_2SO_4 H_2O_2 10 V Nickel Complex $[Ni(H_2O)_6]$ Cl_2

3. Results and Discussion

The results presented in Table 2 show the variations of the parameters analyzed before and after the electrocoagulation, showing the removal of dissolved compounds and the efficiency of the treatment by electrocoagulation/flocculation. The solid residue (treatment sludge) was dried in an oven and subsequently analyzed so that the mass balance of the removed and generated compounds could be checked.

Table 2 Variations in the physical and chemical parameters of the treated residues.

Parameters											
Residue		pH	Conductivity (mS/cm)	Turbidity (NTU)	Alkalinity (mg/L $CaCO_3$)	Chloride (mg/L)	COD (mg/L)	Suspended Solids (mg/L)	Color	Current (A)	Time (hours)
01	A	7.56	2.83	72.2	0.6459	0.9341	693.93	215	Cobalt Blue	4	4
	E	8.52	3.08	2.35	0.43676	0.7144	908.6	22	Slightly bluish	4	4
02	A	7.75	2.70	147	0.7866	0.4161	783.93	171	Cobalt Blue	4	4
	E	9.66	2.54	0.1	0.2647	0.3256	496.93	17	Colorless	4	4
03	A	0.94	2.37	102	ND	0.97	799.93	68	Purple	4	3
	E	9.18	3.52	0.1	0.4932	0.5997	1023.6	18	Colorless	4	3

Residues 1 and 2 presented before the reaction cobalt blue color and parameters suggestive of the presence of weak bases in a dynamic equilibrium, strong base in very diluted solution and hydrolyzable salts, metal complexes Cu (II), Co (II), Cr (II), Pb (I), Ag (I), which generate weak bases and weak acids in aqueous medium. Residue 3 was purple in color with conductivity values between 2.37 mS/cm and pH 0.94 indicating the presence of strong dissociated acids in high concentrations.

After the electrocoagulation process, the pH values of the residues changed significantly. According to Kobya et al. (2006), the variation is attributed to the buffer capacity of the system $Al^{3+}/Al(OH)_3$. For aluminum electrodes in the electrocoagulation-flocculation process, when the initial pH is less than 8, the final pH increases and for higher values the final pH decreases. For each pH range, an aluminum species is released, for example: when the pH is in the range 2-3, Al^{3+} and $Al(OH)_2^+$ species predominate; when the pH is between 4-9, Al^{3+} OH^- ions are generated by the electrodes that react to form species such as $Al(OH)_2^+$, $Al(OH)_2^{2+}$, $Al_6(OH)_{15}^{3+}$, $Al_7(OH)_{17}^{4+}$, $Al_{13}(OH)_{34}^{5+}$, which ultimately become $Al(OH)_3$ by means of complex polymerization/precipitation mechanisms. For pH greater than 8 the concentration of the $Al(OH)^{-4}$ anion increases, significantly reducing the concentration of $Al(OH)_3$ [4].

In addition to the above, when the pH of the effluent remains in the range between 7 and 8, the sweeping flocculation mechanism is favored, especially if the solid form of aluminum hydroxide $Al(OH)_3$ predominates in the liquid medium [5], which explains the pH variation in electrocoagulated residues 1, 2 and 3.

Holt et al. (2002) [6] observed that the species of complexes formed in the oxidation of the aluminum electrode vary depending on the pH of the medium. For pH between 3 and 5, species of the type $[Al(OH)_2^+]$ and $[Al(OH)^{3+}]$ predominate, while for pH greater than 6 the species $Al(OH)_3$ predominates, which can generate a gelatinous layer at a pH above 7.0. According to Chen et al. (2000) [7] the increase in pH can occur from other mechanisms such as the transfer of CO_2, because CO_2 is super-saturated in acidic aqueous electrolyte and can be released from the medium due to the agitation caused by the ₂ bubbles, thus causing the pH to rise.

Before the electrocoagulation-flocculation process, it was observed that in residues 1 and 2 the predominant alkalinity species is bicarbonate ion (HCO_3^-), and it was not detected in residue 3. After the electrocoagulation-flocculation process, bicarbonate and carbonate species were detected in residues 1 and 2 and were not detectable for residue 3. Residue 3 showed 0.6100 mg/L for hydroxyl ions OH^-, not observed in the other residues.

According to Alpha (1998) [3], the total alkalinity of a solution is usually due to the hydroxyl, carbonate and bicarbonate ions dissolved in the water and the sum of

the concentrations of these ions is expressed as calcium or sodium carbonate. Furthermore, these same concentrations may vary according to the pH of the environment in which they are found, as the example in Fig. 3, which shows the variation in the concentrations of alkaline species as a function of pH: The relationship between alkalinity and species concentrations is one of the important points, as it allows us to determine which species will contribute to the value of alkalinity and the function of its pH in the residues. Drawing a comparison with the graph in Fig. 3, we observed that theoretically in the pH value range between 7 to 8 the species with the highest concentration is the HCO_3^- ion, and in pH ranges from 11 to 14 the concentrations of the carbonate ion species (CO_3^{-2}), hydroxyl ion (OH^-) are predominant, suggesting that the alkalinity of residues 1, 2 and 3 has a contribution to the concentration of these species. Residue 3 showed concentration only for the OH^- ion, which justifies the pH > 9 value.

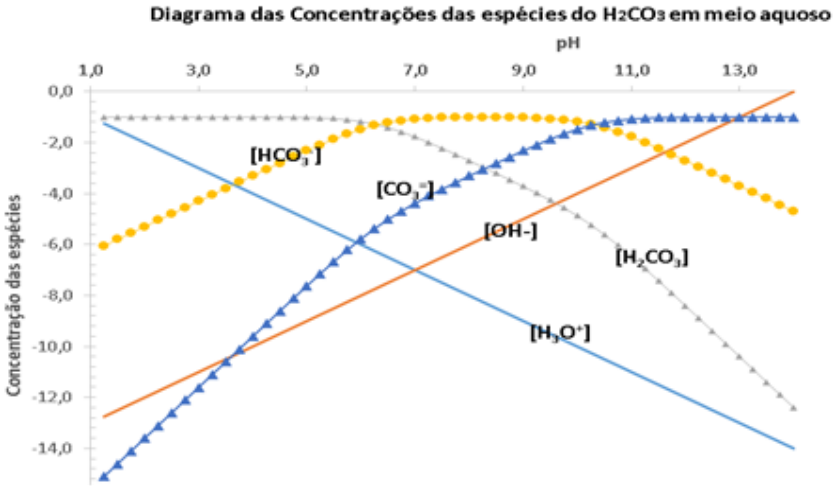

Fig. 3 Diagram of the concentrations of the weak acid species from the hydrolysis of the carbonate ion in the residue.

Residues 1, 2, 3 before electrocoagulation-flocculation showed residual values for chlorides mg/L, 0.9341 mg/L, 0.4161 mg/L and 0.9700 mg/L, respectively, probably from the ionization of hydrochloric acid HCl and the dissociation of chloride salts from alkali, alkaline earth and transition metals. When submitting residues to the electrocoagulation-flocculation process, it is observed that the concentration of the Cl^- chloride ion decreases in all residues: 0.7144 mg/L, 0.3256 mg/L and 0.5997 mg/L, respectively.

The values for electrical conductivity increased for all residues, residue 1 (2.83-3.08 µS/cma), residue 2 (2.20-2.54 µS/cma) and residue 3 (2.37-3.52 µS/cma). The results suggest an increase in molar conductivity as the concentration decreases in chloride and nitrate ions, tending to a maximum value, known as limiting molar conductivity, represented by the symbol $\Lambda\infty$. In this case, we point out the presence of some electrolytes such as sodium chloride (NaCl), nitrates contributing to the increase in molar conductivity (strong electrolytes).

The effluent subjected to the treatment under agitation promotes an increase in the migration of cations and anions from the solution to the electrolyte, causing an increase in the reaction speed and consequently the oxidation of matter. The greater this agitation, the greater the speed of the reaction. This explains the increase in molar conductivity in the residues and a decrease in the concentration of Cl^- chloride and NO_3^- nitrate ions. The flocculation and precipitation of silver chloride and mercury may also be responsible for decreasing the concentration of the chloride ion in residues 1 and 2.

The residues showed high values for dissolved solids before the coagulation-flocculation process, suggestive of the amount of insoluble salts in them. The values

varied after the electrolytic process: 215 mg/L-22 mg/L for residue 1, 171 mg/L-17 mg/L for residue 2 and 68 mg/L-18 mg/L for residue 3. This shows the efficiency of electrocoagulation and flocculation, making residues look limpid and transparent.

The increase in current intensity causes an increase in the migration of cations from the solution to the cathode with the deposition of anion and an increase in the migration of anions from the solution to the anode with the respective deposition of cations into the solution. Thus, an increase in the reaction rate is generated and serves to characterize the equilibrium kinetics by increasing the current density. The answer to the reaction dynamics is to increase the concentration in mg/L of removal of COD (Chemical Oxygen Demand), observed in the treatment of residue 1 (693.93 mg/L-908.60) and (496.93 mg/L-757.93 mg/L) for residue 2 and (799.93 mg/L-1023.6 mg/L) for residue 3, which gives an increase in efficiency in the treatment process. The process proved to be very efficient in decreasing turbidity, which increased during the electrocoagulation reaction and after the electroflocculation decreased to reduced values. All residues had a decrease in initial turbidity and color, thus suggesting a reduction in dissolved compounds.

3.1 Electrode Wear and Aluminum Release

The plates (sacrifice electrodes), Fig. 4, with a total submerged area of 400 cm² each, were weighed before and after the electrocoagulation/flocculation: Plate 1 (325.25 g-314.10 g), Plate 2 (321.64 g-300,88).

Fig. 4 Aluminum electrode.

Mass loss was calculated according to Eq (1):

$$M_{el} = \frac{i \times t \times M}{n \times F} \quad (1)$$

Where i is the current in ampere, t is the treatment time in seconds, M is the molar mass of the electrode's predominant element in g/mol, n is the number of electrons involved in anode oxidation and F is the Faraday constant $9.65 \times 10^4 Cmol^{-1}$.

In the treatment stage there was a significant loss of electrode mass of 5.37g of aluminum for the medium, however the theoretical value of the amount of Al^{+3} released to be consumed during electrolysis as a coagulant doser, is the important mechanism to form aluminum hydroxide $Al(OH)_3$. In fact, according to Meneses et al. (2012) [2], since coagulation is achieved by charge neutralization and destabilization of negatively charged colloids by the cationic hydrolysis of Al^{3+} products, excess coagulant can give a reverse charge and stabilization of colloids.

4. Conclusion

Considering the results obtained in the experiments carried out with the electrocoagulation/ electroflocculation system and analyzing the acceptable limits for legal disposal, issued by CONAMA Resolution 403/2011, it can be inferred that

the system is efficient and removes most of the dissolved substances or in suspension of liquid effluents from teaching and research laboratories. The implementation of a residue treatment program involves an awareness of the need to adopt new habits in order to meet not only the current legislation, but mainly a new mentality that is concerned not only with the quality of the analyzes, but also with residue management. This view involves identifying, treating and referring them, in a way that reduces possible impacts on the environment.

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Evaluation of Particle Size Distribution in the Spodumene Flotation Recovery

João Carlos Martins de Lelis Soares[1], P. R. M. Viana[2], L. G. Parreiras[3], T. G. Silva[3], and C. V. Gusmão[3]

1. Programa de pós-graduação em tecnologia mineral, mestrado profissional, CPGEM/UFMG, Brazil

2. Universidade Federal de Minas Gerias, departamento de engenharia de minas, Brazil

3. AMG-Mineração, Brazil

Abstract: The AMG-mining spodumene flotation is a new route for spodumene concentration in Brazil. It is a major challenge given the limited literature for technical support associated with the operational bottlenecks during the plant commissioning. This work had as main objective to verify the effect of flotation feed granulometry in the lithium recovery for the obtaining of an eventual increase of production. Detailed metallurgical balances were carried out for different particle size distribution and industrial flotation products. The ongoing studies consist of milling the fraction above 149 μm followed by flotation of the ground product with the aim of increasing the metal recovery. In order to improve the lithium recovery in fractions above 149 μm, industrial scale tests should be performed on the plant, increasing the flotation cells agitation during the rougher flotation stage and increasing the conditioning time.

Key words: flotation, spodumene, particle size distribution, recovery

1. Introduction

As technology develops and with the likely future high demand for battery power for hybrid and electric cars, lithium becomes a unique metal with great use prominence since it has interesting features such as a low density metal, high electrochemical potential, and high emphasis on the relationship between weight and energy capacity.

The countries that have the largest lithium reserves are Bolivia, Chile, China and the United States. In terms of production, Chile and Australia stand out in the international market.

The largest lithium producing companies can be cited as Albemarle in Chile, SQM in Chile, Talison Lithium in Australia and Ganfeng Lithium in China.

Brazil, according to CPRM Geological Survey 2017 [1], has reserves in the order of 48,000 t of contained lithium, with an annual production of approximately 200 tons of contained lithium.

Taking this context into account, AMG Mineração's Lithium Project, where lithium production occurs from the reuse of tantalum concentrate processing tailings, has been in operation since mid-2018.

The implementation of the Lithium Project industrial complex (capacity of 90,0000 t/year of spodumene concentrate), located in the municipality of Nazareno, State of Minas Gerais, Brazil, began with the installation of a spodumene concentration plant, officially inaugurated in mid-2018. The implementation of this first phase of the project has mobilized, over the last nine years, about 40 outsourced companies and more than two thousand direct and indirect professionals.

AMG Mineração is currently directing part of its efforts towards the development of the subsequent steps of the lithium carbonate and hydroxide production process. This work is expected to be completed later this year and will enable the start of

Corresponding author: João Carlos Martins De Lelis Soares, Mining Engineer; research area/interest: mining. E-mail: joaocarlosmls@gmail.com.

operations of the lithium carbonate and hydroxide chemical unit in 2021. This project is enabling the company to become one of Brazil's largest lithium producers and a reference in the mining when it comes to maximizing mineral resources.

A company that stands out in the Brazilian mineral scenario with the production of Tantalum concentrate, being one of the reference companies in this segment of the mineral industry. Currently AMG has started operation of a new spodumene concentration plant.

The spodumene plant was inaugurated in the first half year 2018, with the challenge of producing spodumene concentrate by the flotation mineral concentration method and also several steps common to a beneficiation plant, such as grinding, classification, desliming, thickening, filtration and drying.

The objective of the present study was to evaluate the flotation feed particle size distribution, with analysis of metallurgical and mass recovery of beneficiation plant, in order to determine how the feed grain size used in the process can increase or decrease the spodumene recovery in the flotation stage.

VIANA (2006) [2], says that the most common lithium-bearing mineral in Brazil is spodumene silicate. In the Brazilian territory, production is practically restricted to pegmatites from the northern region of Minas Gerais. The separation of spodumene from quartz, feldspars and micas, silicates most commonly associated with the main mineral is generally performed by hand pick or gravity separation in dense medium. Both flotation operation and magnetic separation are methods employed in the largest operations in the world, and are also used in AMG-mining.

According to Lima and Valadão (2008) [3], flotation is one of the main concentration processes, being used for the most diverse minerals, such as iron, copper, phosphate, among others. Considering that flotation is normally employed for particle size ranges between 10 and 300 micrometres, the selectivity of the flotation process becomes very low outside these particle size limits, because of the hydrodynamic conditions of the system are unable to maintain the optimum flotability level of the particles.

For Leja (1982) [4] the maximum feed size for a flotation system can be set as a function of the ore liberation size. However, in many cases this size is limited by the force of adhesion between particle and bubble.

In AMG-Mineração [5], the liberation of the spodumene mineral is in the size range of 200 μm to 250 μm.

1.1 AMG-Mineração

AMG-Mineração produces highly engineered specialty metals and mineral products and provide related vacuum furnace systems and services to the transportation, infrastructure, energy, and specialty metals and chemicals end markets.

AMG Critical Materials produces aluminum master alloys and powders, ferrovanadium, natural graphite, chromium metal, antimony, lithium, tantalum, niobium and silicon metal. AMG Technologies produces titanium aluminides and titanium alloys for the aerospace market; designs, engineers, and produces advanced vacuum furnace systems; and operates vacuum heat treatment facilities, primarily for the transportation and energy industries.

With approximately 3,300 employees, AMG operates globally with production facilities in Germany, the United Kingdom, France, the Czech Republic, the United States, China, Mexico, Brazil, India, Sri Lanka, and Mozambique, and has sales and customer service offices in Russia and Japan.

1.2 Lithium Project Overview

As a global critical materials company at the forefront of CO_2 reduction trends, AMG entered the lithium market in 2016 with an investment of approximately $50 million in the construction of a lithium concentrate (also known as spodumene) plant at its existing Mibra mine in Brazil.

Leveraging its existing mining infrastructure in place at Mibra (which has been in operation for almost 40 years), AMG's goal is to be the low-cost producer of lithium concentrate globally. AMG can recover lithium-bearing materials from the existing and future tailings at its profitable tantalum operations at Mibra, with the ore extraction and crushing costs absorbed by the Tantalum operations. AMG has successfully operated a lithium pilot plant since 2010, with more than 2.8 million tons of spodumene feed stock having been extracted. The project involves the construction of a lithium concentrate plant to produce 90,000 MT of spodumene per year, with operations having commenced in May 2018. The recent mineral resource estimate for Mibra (published in April 2017 and prepared in accordance with National Instrument 43-101 Guidelines) identified 20.3 million MT of measured and indicated resources, which includes lithium, tantalum, niobium, and tin.

1.3 Concentrate Spodumene Plant

In short the material flow in the beneficiation plant occurs: the new feed, which can be pumped from the tailings of the Tantalum Plant 1 and 2 or being feed via a loader stack or truck in the hopper present in the plant area. After the spodumene concentrate plant has been feed, there is a classification step so that the underflow is directed to the mills feed and the overflow is directed to the next phase of the desliming (reverse circuit). In the desliming step, slimes are removed from the material and the overflow (slimes) is directed to the slimes thickener and magnetic tailings and then pumped to tailings dam 3. The desliming underflow is directed to the separation step, where the magnetic tailings are directed to the magnetic tailings and slimes thickener and are subsequently pumped to dam 3. The non-magnetic material proceeds to the thickening step and then feeds the conditioning tanks that feed the flotation cells. Spodumene flotation has two concentration stages, rougher and cleaner. The rougher stage tailing is the final flotation tailing and the cleaner stage tailing is returned to the rougher stage feed as a circulating flotation load. Flotation tailings are thickened and pumped to tailings dam 3 or Feldspar Plant. The flotation concentrate proceed to the dewatering stages where it is thickened, filtered and dried to obtain a moisture bellow 2%, and directed to the quality control and storage silos and subsequent bagging and shipping.

1.4 Flotation

Flotation is a physical chemical process that exploits different characteristics of the particles surface. Concentration occurs when minerals particles that are hydrophobic trough surface modification by reagents are collected by air bubbles introduced in the system and are discharged in the equipment overflow. Minerals that are hydrophilic in nature or by surface modification are discharged in the bottom of the flotation cells.

Concentration of the ore mineral can occur either by overflow (direct flotation) or by underflow (reverse flotation) in the products of flotation machines, depending on each process and ore worked. Among the several operational variables of the flotation process we highlight the solids percentage, aere aeration/agitation, conditioning time, flotation time, flotation feed size and liberation degree.

2. Material and Methods

Fig. 1 shows a schematic flowchart of the spodumene flotation.

The collector reagent for spodumene flotation and caustic soda for pH regulation are added in the conditioning tank. From the conditioning step the material goes to the rougher stage composed by 5 mechanical cells (Outotec TankCell), where the tailings of this step is the final tailing and the concentrate goes to the cleaner stage composed by 4 mechanical cells (Outotec OK-Cell), where the concentrate of this stage is the final concentrate and the tailings are returned to the rougher stage.

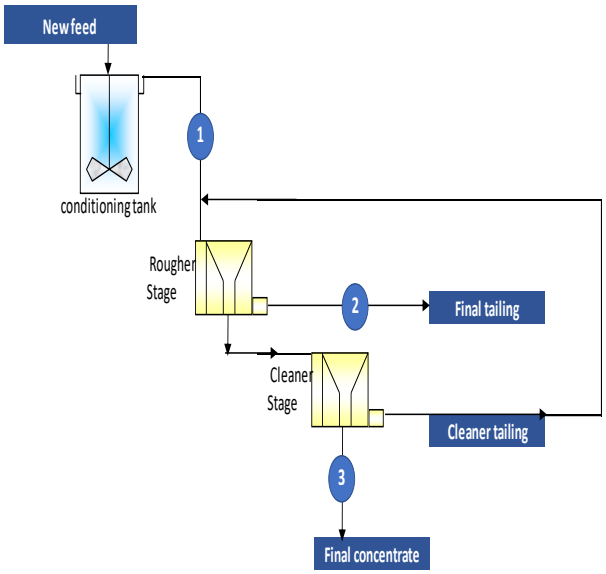

Fig. 1 Flotation flowchart with sample collection points.

To know and evaluate the influence of the flotation feed size on the recovery of Li_2O, a circuit mass balance was done to perform the recovery calculations to know the chemical contents by each particles size of the flotation feed (1), final tailings (2), and final flotation concentrate (3).

Therefore, it was possible to determine the recovery by particle size distribution of the spodumene flotation. Regarding the specification of the products on the market, they are characterized by their Li_2O and Fe_2O_3 contents. Usual specifications are Li_2O greater than 5.5% and Fe_2O_3 less than 0.8%.

2.1 Metallurgical Recovery by Particle Size Distribution

One way to measure the efficiency/influence of particle size on flotation performance is to evaluate each particle size range separately, obtaining their respective recovery values.

For this it is necessary to have ore contents in the feed, concentrate and tailings, in particle size ranges (granulochemical analysis). These grades are used in Eq. (1) below to determine metallurgical recovery:

$$Metallurgical\ recovery = \frac{c(a-r)}{a(c-r)} \quad (1)$$

c: ore content in the concentrate.

a: ore content in the feed.

r: ore content in the tailings.

With the contents in each particle size range, feed, concentrate and tailings, it may be possible to obtain the recovery of the ranges and perform a better evaluation on them.

3. Results and Discussion

The following tables present the results of the physical and chemical analyzes performed by the AMG-mining chemical and physical laboratory after sample collection and analysis. The chemical analyzes were performed via ICP equipment (inductive coupling plasma) and the particle size analysis was made wet by sieving using the selected particle size ranges.

Therefore, these tables show the chemical analysis, particle size distribution and metallurgical recovery data of Li_2O and Fe_2O_3 in the 177 µm, 149 µm, 105 µm, 53 µm, 44 µm and <44 µm ranges.

Tables 1, 2 and 3 present the information regarding feeding, concentrate and flotation tail respectively.

3.1 Data Analysis

For a better understanding of the collected data, the graphs of Figs. 2 and 3 were made for the analysis of the mass and metallic recovery.

Fig. 2 shows the mass recovery of spodumene flotation by size fraction.

Fig. 3 shows the metallic recovery of spodumene flotation by particle size distribution in relation to Li_2O and Fe_2O_3 oxides.

The low recovery of Li_2O can be clearly seen from Figs. 2 and 3 in the particle size ranges above 149 µm, and these particle size ranges represent approximately 50% of the mass flotation feed. It is noteworthy that the Li_2O content in these ranges can be rated as a good Li_2O content (1.2% average). Therefore, it can be said that one of the causes of the tailings having a Li_2O content of 0.56% (target 0.32%) is due to the low recovery of spodumene particles in these particle size ranges.

Table 1 Flotation feed data analysis by size.

Particle size distribution flotation feed		Contents		Recovery	
Size	**Simple Retain**	**Fe_2O_3**	**Li_2O**	**Fe_2O_3**	**Li_2O**
177 µm	22.1%	0.4%	1.0%	100.0%	100.0%
149 µm	27.3%	0.3%	1.5%	100.0%	100.0%
105 µm	19.5%	0.3%	1.4%	100.0%	100.0%
74 µm	14.3%	0.3%	1.4%	100.0%	100.0%
53 µm	9.5%	0.4%	1.5%	100.0%	100.0%
44 µm	3.6%	0.5%	1.6%	100.0%	100.0%
< 44 µm	3.6%	0.7%	1.7%	100.0%	100.0%
	100.0%	**0.3%**	**1.3%**	**100.0%**	**100.0%**

Table 2 Flotation concentrate data analysis by size.

Particle size distribution flotation concentrate		Contents		Metallurgical Recovery		Mass recorvery
Size	**Simple Retain**	**Fe_2O_3**	**Li_2O**	**Fe_2O_3**	**Li_2O**	
177 µm	0.9%	0.7%	5.2%	63.0%	28.0%	5.0%
149 µm	4.1%	0.5%	6.1%	65.0%	56.0%	13.0%
105 µm	17.4%	0.5%	6.2%	66.0%	69.0%	15.0%
74 µm	19.6%	0.6%	5.8%	76.0%	77.0%	19.0%
53 µm	16.6%	0.8%	5.0%	46.0%	81.0%	24.0%
44 µm	14.1%	1.1%	4.3%	74.0%	86.0%	33.0%
< 44 µm	27.3%	1.7%	3.6%	86.0%	87.0%	41.0%
	100.0%	**1.0%**	**4.9%**	**57.0%**	**65.0%**	**18.0%**

Table 3 Flotation tailings data analysis by size.

Particle size distribution flotation tailing		Contents		Metallurgical Recovery	
Size	**Simple Retain**	**Fe_2O_3**	**Li_2O**	**Fe_2O_3**	**Li_2O**
177 µm	32.0%	0.2%	0.7%	37.0%	72.0%
149 µm	14.3%	0.1%	0.7%	35.0%	44.0%
105 µm	19,5%	0.1%	0.5%	34.0%	31.0%
74 µm	12.4%	0.1%	0.4%	24.0%	23.0%
53 µm	9.2%	0.3%	0.4%	54.0%	19.0%
44 µm	4.3%	0.2%	0.3%	26.0%	14.0%
Fundo	8.3%	0.2%	0.4%	14.0%	13.0%
	100.0%	**0.2%**	**0.6%**	**43.0%**	**35.0%**

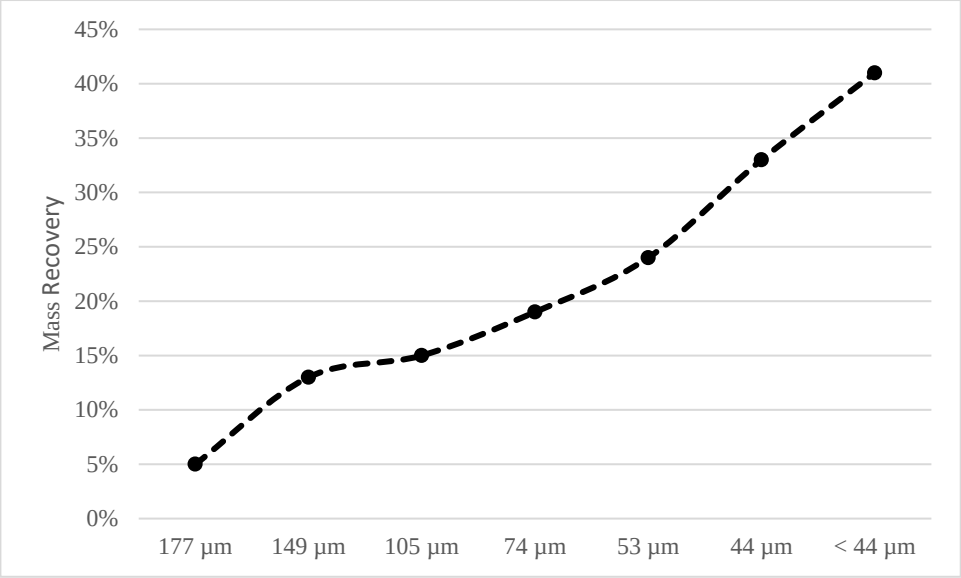

Fig. 2 Mass recovery by particle size distribution of spodumene flotation.

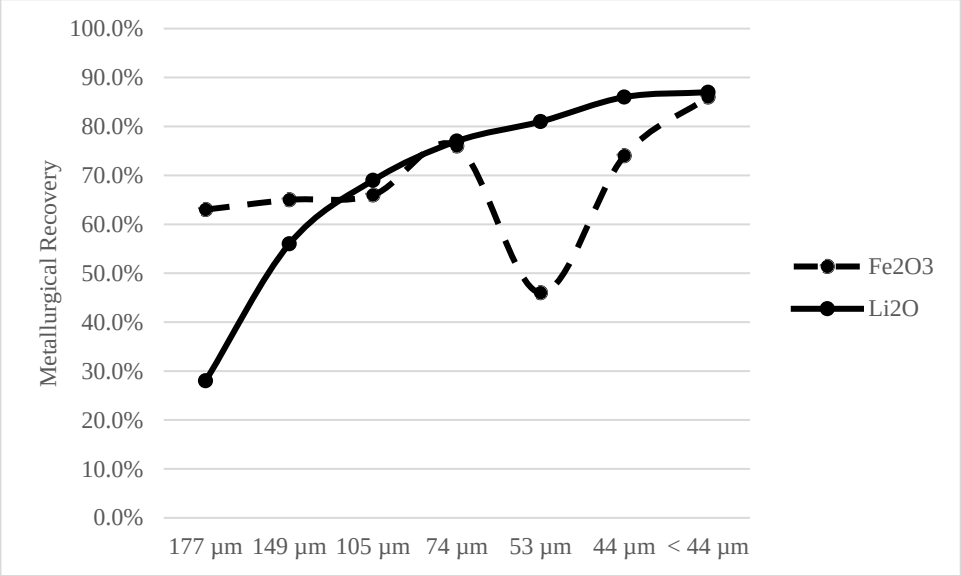

Fig. 3 Metallurgical recovery by particle size distribution of spodumene flotation.

Regarding Fe_2O_3, which is a contaminant of spodumene concentrate, Fig. 3 shows that the recoveries are above 60% in all ranges except 53 µm, where it should be better evaluated following the work to understand the reduced recovery in this range. It is noteworthy that one of the one way to increase the global mass and metallurgical recovery, currently being investigated, is the reduction of flotation feed grain size. In this milling situation of the coarser fraction of the feed, care should be taken with the Fe_2O_3 content in the concentrate due to the higher generation of fine particles < 44 µm which are generally rich in Fe_2O_3 and are being floated with a high metallic recovery index (86%), which in the current situation, leads to a high Fe_2O_3 content (1.70%) in this narrow concentrate range.

4. Conclusion

Based on the analyzes performed in the present study, it was found that particle sizes above 149 µm in the flotation feed, which represent approximately 50% of

the flotation feed mass, contribute significantly to the reduction of Li_2O recovery.

Therefore, the identification of lower recovery in fractions +149 μm is one of the great opportunities to increase the recovery/production of spodumene flotation. Possible actions/studies to increase recovery in this fraction include the modification of pulp agitation in cells, reagent conditioning time with pulp, coarse flotation (+149 μm) separately, or even material grinding +0.149 μm to reduce the particle size of the flotation feed since particle size is a major factor influencing flotation.

In this way, one of the steps of this investigation will be the milling of the +149 μm feed fraction only, followed by separate flotation of the milled ore, as well as the flotation of the milled ore together with the -149 μm natural material in bench/pilot scale, aiming further analyzed the behavior of this fraction because of the high potential for increased recovery of Li_2O in the concentrate.

In order to create a more robust database regarding the process and greater assertiveness in decision making, the analysis of recoveries by particle size range of the flotation should be continued. As well as more details about this work, such as flotation process data (volume, pH, rotation, air flow, etc.), can be viewed in the master dissertation by CPGEM/UFMG that is being prepared by the first two authors of this article.

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ZEB Prototype Controlled by A Machine Learning System

Federico Cinquepalmi[1], Sofia Agostinelli[2], and Fabrizio Cumo[2]

1. Italian Ministry of University and Education, Rome, Italy

2. CITERA – Sapienza University of Rome, Italy

Abstract: This communication concerns a research project by the Interdepartmental Research Centre for Territory Construction Restoration and Environment (CITERA) of Sapienza University of Rome in collaboration with ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) based on the realization of a 1:1 scale demonstrator of a Zero Energy Building (ZEB) that allows continuous experimentation of new technologies for innovative photovoltaic systems, efficient storage systems and high-performance envelope materials. In particular a measurement protocol has been developed for both the overall efficiency of the building and the individual technological components with a view to a comparative critical analysis of the integration of the individual components in the building-system complex. All the technological systems has been used in Solar Decathlon Middle East 2018 competition in Dubai. The project concerns the development of a control and management system for photovoltaic energy production systems for the ZEB prototype, based on an intelligent self-learning system (AI) able to optimize the parameters of self-produced electricity supply based on real consumption of air conditioning equipment, electrical power supply to the equipment, access control and safety equipment. The most immediate result concerns the integrated design of both the hardware systems for the production and use of electricity and the algorithms that continuously measure parameters such as grid load, consumption and electricity production, and which takes into account weather forecasts, energy tariffs, and learns the trend of electricity consumers through the use of artificial intelligence.

Key words: Zero Energy Building (ZEB), machine learning control, energy efficiency

1. Introduction

One of the most interesting aspects of the evolution of contemporary cities is related to computational technologies, conveniently integrated into buildings. Despite being considered a consolidated process, the binomial building/electronics is having in recent years, developments deserving a deep reflection. Contemporary buildings design evolves using the best available technologies, in order to face societal challenges and perform in an increasingly "smart" way, for the assurance of "human needs". The initial steps were certainly the integration of the already existing and well-tested domotic technologies applied to domestic environments, but the real paradigm shift will be represented by the integration of artificial intelligence in its declination of machine learning.

This would be a real Darwinian co-evolutionary process where housing units "learn" to adapt themselves to the human demands and needs, even if unclear or unexpressed. This is leading to a huge variety of possibilities: buildings equipped with advanced sensors and able to perceive the internal and external conditions will optimize their energy consumption with strategic savings for single inhabitants, community and environment, and while respecting the needs of the residents the house. Those "intelligent" systems will safeguard residents from unauthorized intrusion, interacting with them in an

Corresponding author: Federico Cinquepalmi, Professor; research area/interest: project management, applied physic. E-mail: federico.cinquepalmi@miur.it.

increasingly comfortable and smart way, contributing to ensure to disadvantaged categories (like elderly people, children and disabled) a substantial support to care. The so-called artificial intelligence is anyway just an extra tool for the analysis of the reality, elaborating different scenarios, exploiting the high capacities of modern computer systems using advanced statistical algorithms, simulating human capacities of choice. Sapienza University of Rome in collaboration with ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development), propose an innovative house design concept, developed for the Solar Decathlon Middle East 2018 competition, where the Sapienza Team designed and realized a prototype of a house entirely powered by solar energy. The engineering components, technology and management systems, matter of technological experimentations both in Italy and Dubai, are the "core" of the present project, revisited in order to fit the Mediterranean climate. The goal is to realize a building classified as a Zero Energy Building (ZEB), based on BAT together with the principles of Energy Efficiency, Home Automation and Smart System Management. This domestic environment highly integrated, will be equipped with elements of artificial intelligence (AI), adapting the house both to internal/surrounding environment and to the user profile and needs.

2. Design and Realization of the Experimental Prototype

The main goal of the project will be dealing with the new challenges of contemporary society, with a new integrated approach to buildings design, construct and managing. Main objective is to create a Smart/intelligent Solar House able to ensure efficiency and effectiveness, but also to provide an attractive, accessible, safe, comfortable built environment, competitive in terms of costs and able to improve the quality of life. According to the italian tradition, it is introducing a new approach to Architecture, able to exploit all possibilities offered by the use of microgenerated renewable energy and highly innovative technology and construction solutions with low environmental impact. The project is focused: not only to the energy and environmental efficiency, usually connected to Zero Energy and Green Buildings, but also on intelligence and flexibility criteria, through a continuous interaction with internal/external natural and built environments. Gathered data and information will be used for building optimization and quick adaptations to changes, even in the structure and size, meeting the evolving needs of the family, and adapting also to existing buildings.

According to the innovativ model of Architecture 4.0, the project will apply and test the most advanced tools, materials and technologies available today in the building industry., Taking advantage of the huge and still partially unexplored potential offered by digital modeling (BIM), mixed reality (virtual reality and augmented reality) and 3D printing, the project is taking into account all different aspects of the building design, while focusing on innovative design and materials, renewable sources and the latest generation Home Automation Systems (machine learning, virtual assistant, intelligent app). Therefore the objective of the project is at the same time at a typological level (smart shape), relating to the shape and orientation of the building, positioning and sizing the openings and the distribution of interior spaces, in order to promote natural lighting and ventilation, the use of renewable energy and the reduction of energy needs; at a technical-constructive level (smart snvelope), concerning both the characteristics of the structure, in order to maximise its resilience and flexibility and reduce construction costs and times, and the thermohygrometric characteristics of the envelope in order to reduce energy requirements and maximise levels of thermal, acoustic and luminous comfort; at a technological level (smart systems), promoting the use of high-efficiency solutions, the integration of renewable energy sources and the use of advanced Building Automation and Internet of Things (IoT)

systems in order to reduce the consumption of primary energy from non-renewable sources and maximize the levels of internal comfort; at a socio-cultural level (smart people) through training and directly involving users who will be able to manage energy consumption and comfort levels in the best possible way and in a conscious manner through the use of home automation systems.

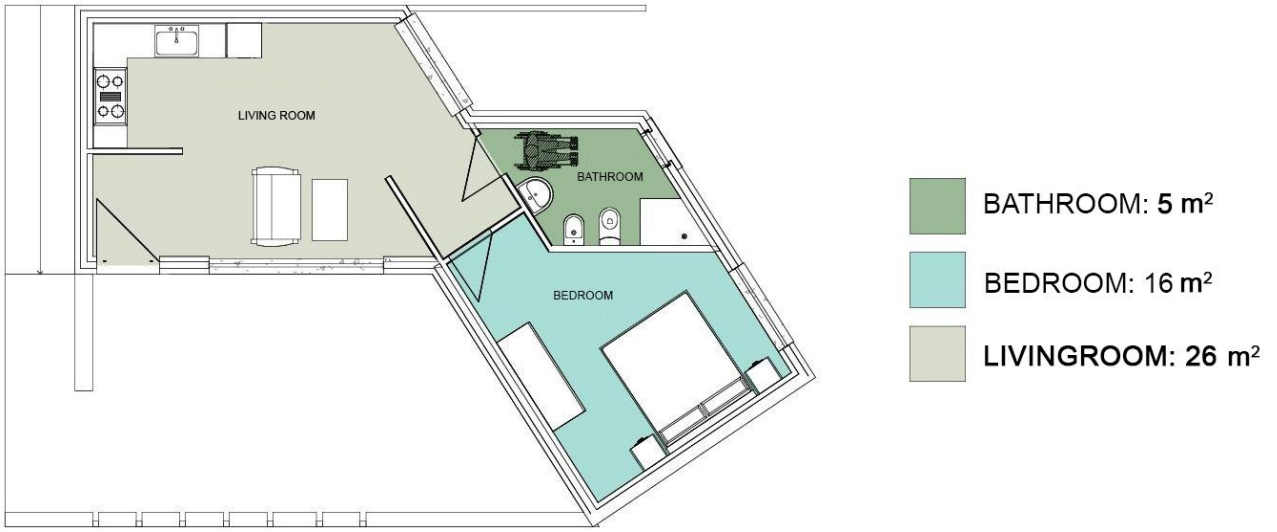

Fig. 1 Solar House: Ground floor functional layout.

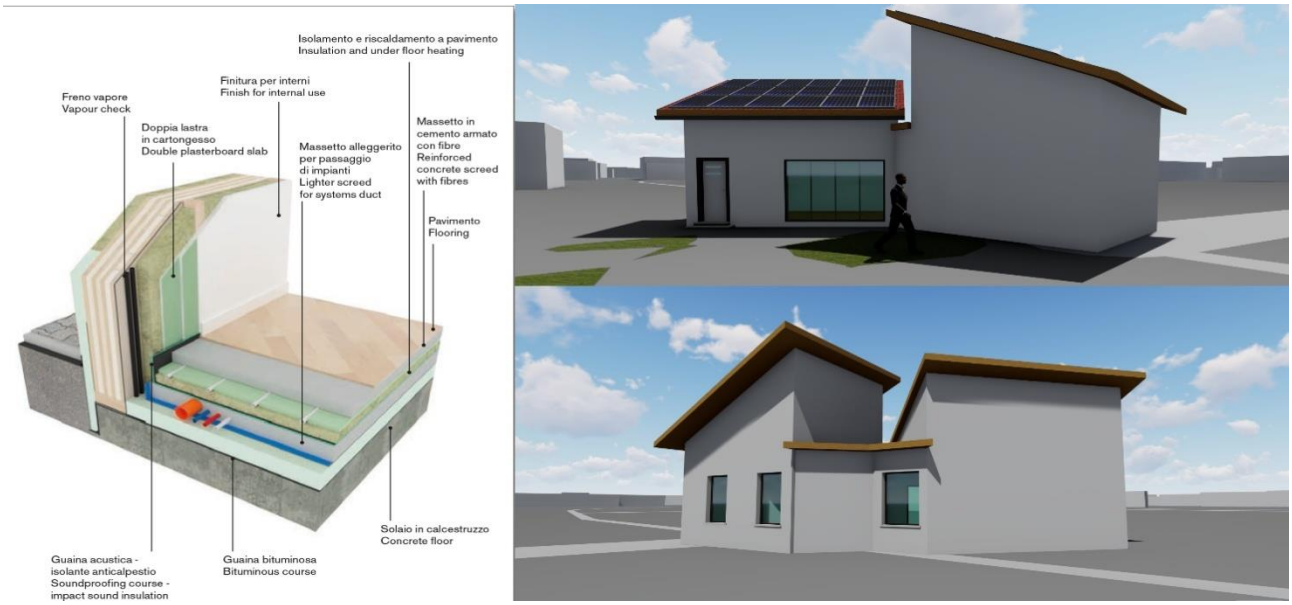

Fig. 2 Xlam Dolomiti Production technological section: example of wall-raft foundation stratigraphy and render views.

The criteria underlying the design concept are those of bioclimatic architecture and sustainable design, based on a strategic approach that allows to fully exploit the climate and the context in which it is located, realizing the construction through a rational use of climatic and energy resources in order to ensure environmental well-being. The object is the result of a study aimed at the environmental quality and the relationship/continuity between indoor and outdoor environments with particular focus on the following aspects: *form and orientation*: analysis and monitoring of climate parameters (use of ENEA climate station data); *choice of materials and components of the building envelope*: performance, comfort,

standardization, regenerable materials; *internal distribution choices:* comfort, functions; *sustainability:* use of natural resources and renewable energy sources; *standardization/pre-fabrication*: development of a reproducible model for the realization of innovative components constituting the building envelope. The components of the building/systems are designed and built with standardization criteria using technologies strongly oriented to prefabrication that allow a significant reduction in time and cost of construction, as well as energy consumption and environmental impact. Even the technological and system elements are mainly oriented to the concepts of standardization, realized with "plug and play" assembly method and integrated with managementand control systems that allow to be updated and/or self-learn from the response to certain stimuli, optimizing the management of the building-system throughout the useful life of the demonstrator.

The project is a prototype for a single-family home with a net area of 47 m^2 organized in four areas: living area with open space kitchen, double bedroom and bathroom, related to a privat patio.

The pitched roof is designed integrating a photovoltaic system (32 modules) with an implemented automation system able to manage and control the domestic consumption through the management of the external envelope (opaque, transparent, shielding), ventilation, lighting, winter/summer air conditioning, hot water production, IAQ control, microclimate parameters, home automation users and security systems. The construction system proposed, is the innovative XLAM wood technology, a new way to conceive load-bearing surfaces compared to framed or trellis wood systems, introducing the panel as a new basic element for wooden construction. The XLAM panel is an engineered wood product composed of at least three layers of spruce boards, crossed and glued together. This technology made possible load-bearing surfaces that can already be "cut-out", depending on architectural requirements, for doors, windows and stairwells, relying on a high degree of prefabrication. The layers composing each panel are in the minimum resistance class C24-S10 and are pre-fabricated, classified and joined by finger joints, in order to ensure structural continuity between the lamellas that make up the single layer. The structures made of XLAM have characteristics of environmental sustainability, energy saving, seismic and fire resistance and are used in the construction of the load-bearing elements of the building such as walls and floors.

3. Measurement and Monitoring Protocol

After designing the experimental section, CITERA and ENEA have developed a Measurement and Monitoring protocol based on the requirements imposed by the Solar Dechatlon competition in terms of energy efficiency, energy management and sustainability. As shown from the graph in the Fig. 4 these three criteria, were among the most important of the building presented for the competition, but unlike the communication architectural design and sustainable transportation, are likely to be further improved. So to evaluate the house's electrical energy self-sufficiency, management and reduction of energy consumption has been realized a monitoring and measurement system, collecting data of the different electric energy flows during the house functioning period. The main parameter monitored every ten minutes are the electricity consumed for heating, cooling, ventilation and lighting, the electricity consumed by other house loads, load consumption for surface area, net electrical balance and temporary generation consumption. Moreover the system will evaluate the functionality and efficiency of the house design, systems and components, in addition to their contribution in reducing energy consumption, demonstrating the higher level of functionality of the house structure, envelope, electricity, plumbing, HVAC, solar system, and their integration monitoring profile pattern correlation and efficiency of

demand-response devices. Many sensors integrated in the bacs equipment will evaluate the capacity for providing interior comfort through the control of temperature, humidity, lighting, quality of interior air and acoustic performance.

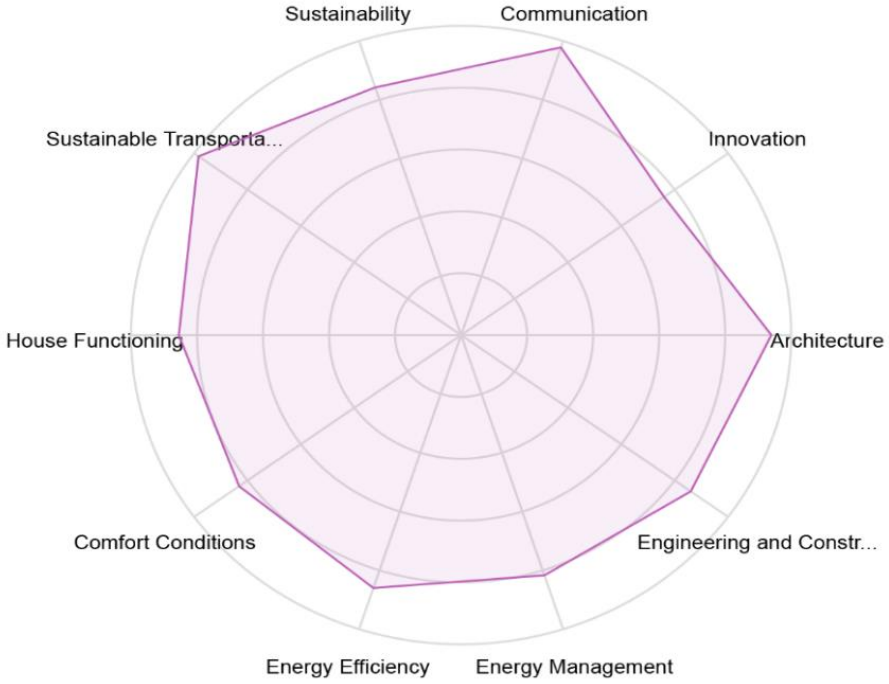

Fig. 3 Quality requirements.

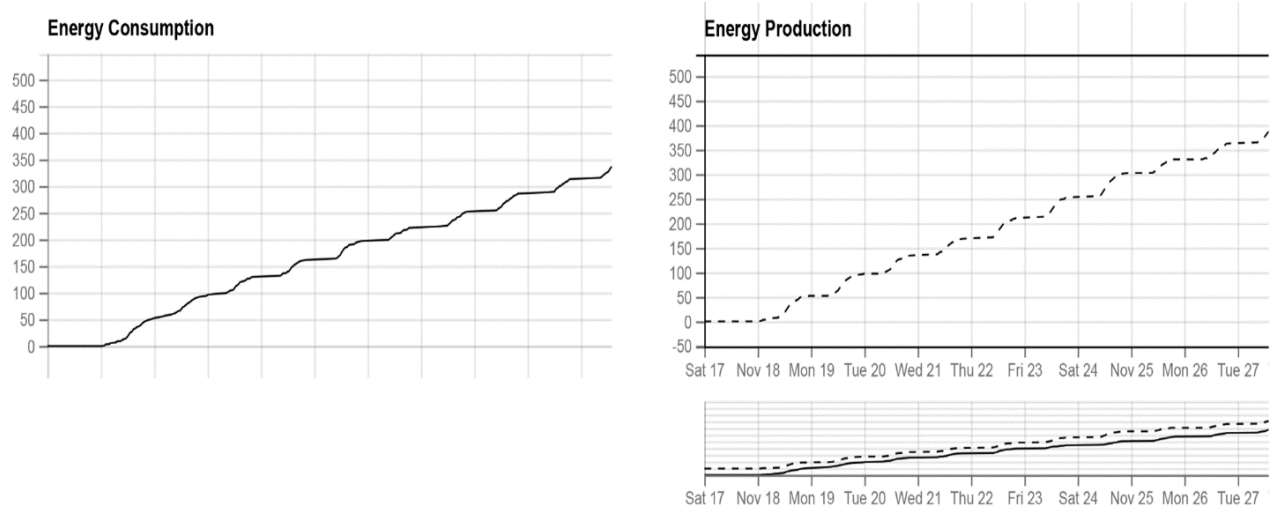

Fig. 4 Overall energy consumption vs energy production through PV system.

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Many sensors integrated in the bacs equipment will evaluate the capacity for providing interior comfort through the control of temperature, humidity, lighting, quality of interior air and acoustic performance.

As an example of the monitoring systems outputs in Fig. 5 the net electrical balance in real time of house energy production through PV system versus overall energy consumption is shown.

4. AI Systems for PV Production Systems

In order to further improve the performance of energy efficiency, energy management of the demonstrator it was decided to integrate the AI and Machine Learning in the base system through the use of the so-called “neural networks”, computational systems that are inspired by our nervous system. The human being, therefore, only has to monitor this learning process, correcting the program when it fails and providing positive feedback when it operates correctly. These computational learning techniques based on artificial intelligence have recently begun to take hold in the energy sector as well. In fact, the International Energy Agency (IEA) predicts that even in the energy field AI will be decisive in the years to come and will transform global energy systems in a fundamental way, making them more interconnected, reliable and sustainable. In the field of clean energy production and energy consumption in general, there are many complex problems to which AI can find solutions and there are already many projects started on the basis of this technology.

As far as the production of energy from renewable sources is concerned, it is well known that uncertainty about weather conditions is a major problem. Being heavily dependent on photovoltaic or wind power systems is risky because, in case of bad weather conditions, the supply of energy should be compensated by other sources, a very expensive and unsustainable operation. It is therefore reasonable to think of AI to deal with these problems and optimize the production, transmission and storage of energy produced by photovoltaic or wind systems scattered throughout the territory. By integrating in real time meteorological data with those from satellites, artificial intelligence systems are in fact able to identify recurring patterns, maximize efficiency and minimize the risks for the supply of electricity.

At the local level of microgrid domotics for reducing energy consumption and energy efficiency in buildings, the AI is perhaps having an even more decisive impact. IoT systems are based on a network of sensors that measure and communicate with each other via the Internet, providing a very large amount of data that is then processed and translated into efficient solutions. The domestic sector represents one of the sectors with the greatest potential as it is estimated that by 2040 there will be one billion “Smart Homes” and 11 billion smart appliances in the world, the optimization of which through artificial intelligence would allow a reduction of more than 10% of domestic energy consumption. In addition to the fact that these interconnected networks are already producing an enormous amount of data that can be used by utility companies, solutions aimed at consumers will also come shortly afterwards. Monitoring the use of household appliances, for example, can generate data that allow, with AI tools, to estimate the costs and project them on the hypothetical bill at the end of the month, helping the user to make the most sustainable choices.

In practice, the built-in artificial intelligence software, in fact, records and interprets the energy needs of the family and then actively intervenes and eliminates all unnecessary consumption. If, for

example, the solar energy reserves are about to run out, then the system can automatically turn off a television set or turn down the lights at home, or even reduce the volume of the stereo or the intensity of a fan.

At the level of control and management of the photovoltaic energy production system with which the demonstrator is equipped then Artificial Intelligence (AI) techniques can be applied to three main areas: (1) Forecasting and modelling of meteorological data, (2) Basic modelling of solar cells and (3) Sizing of photovoltaic systems.

Artificial intelligence (AI) infact can monitor multiple solar PV plants and its overall status, by integrating various data such as in power generation, maintenance needs, and power generation efficiency in real time. In particular, platform enables on-demand maintenance services by tracking and forecasting various factors that are crucial to solar power generation, such as in hardware maintenance and partial component installations. Through real-time AI analysis, the system can notify users of potential power plant malfunctions, forecast power generation, and provide comprehensive database for efficient operations of solar power plants.

5. Conclusions and Further Development

Although this project is limited to an application of AI systems to a microgrid domotics, there is no doubt that there is a great potential for these technologies in the near future of other sectors at national and global level related to the world of energy. It is therefore reasonable to take a close look at the various projects and applications of the AI aimed at increasing the efficiency of renewable sources and making everyday consumption more sustainable. The future logic in fact, to reach the 2030 objectives, is that it is not enough to have systems for the production of energy from RES installed in homes according to the logic of distributed micro-generation and local smart grid.

In order to save and correctly manage the self-produced energy, there must be a control and management system capable of learning our consumption habits and, from time to time, of programming the system according to our needs. The acquisition and management of Big data, managed by artificial intelligence, will make it possible to cross-check in real time consumption data, self-production data and data from the market, strategically deciding the best option, without penalizing the environmental quality of the buildings in which we live. This will be done, regardless human intervention, while customizing consumption profiles based on the real needs of users of a given environment.

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Study of the Separation of Samarium and Europium Through Solvent Extraction

Gabriel Santos, and Ysrael Marrero Vera
Center for Mineral research, Brazil

Abstract: The growing importance of rare earth elements (REEs) in recent decades is due to the large number of high technology applications. Currently, the separation of the REEs in industry is carried out mainly by solvent extraction (SX), and among the most common types of extractant are organophosphorus acids. The separation of adjacent rare earth elements is a major challenge due to the similarity in their chemical behavior, resulting in low selectivity of the extraction process. The addition of lactic acid in the extraction system can improve the extraction and selectivity of separating the elements europium (Eu) and samarium (Sm). The objective of this work was to compare the continuous solvent extraction of Sm and Eu with or without lactic acid in the extraction system. Continuous solvent extraction experiments showed that the addition of lactic acid favored extraction and selectivity of Sm/Eu separation. The best performance was achieved with a mixture of P507 (8%), D2EHPA (2%) and 0.3 mol L^{-1} of lactic acid, at pH 3.0, resulting in 96.5% recovery of europium in the organic phase. Future experiments will focus on the scrubbing of the loaded organic phase produced in the extraction stage.

Key words: samarium, europium, solvent extraction, rare earth elements

1. Introduction

Rare earth elements (REEs) are essential to high-technology industries. Among their most important applications are the manufacture of catalysts of chemical reactions such as crude oil cracking, lasers, special metal alloys, and magnets to generate high-intensity magnetic fields (used in mobile devices), hard drives for computers, aerogenerators and electric motors. These applications are expected to expand dramatically with the progressive shift from reliance on fossil fuels to greater use of renewable energy sources, such as wind and solar power, including the growing use of electric and hybrid vehicles [1].

Solvent extraction is the most widely employed technique to separate REEs, and organophosphorus acids are the most common extractants used industrially [2]. The separation of REEs by solvent extraction has been studied in recent years at the Center for Mineral Technology (CETEM) from Brazil. CETEM is a Research Center under the Ministry of Science, Technology, Innovation and Communication. These studies have focused on, among other topics, the separation of light and heavy REEs [3] and the separation of light REEs employing organophosphorus acid extractants [4, 5].

A research project was recently started at the CETEM involving the separation of medium and heavy REEs from a chloride liquor of these elements. In a previous study, batch solvent extraction tests were performed to define the best conditions for separation of samarium and europium (pH of the feed solution; concentration, saponification degree and pH of the extractant; and concentration of lactic acid in the aqueous feed solution) [6, 7]. This work is a continuation of that study for Eu/Sm separation, now starting a new step, analysis of the separation in continuous solvent extraction.

Corresponding author: Ysrael Marrero Vera, Ph.D.; research areas/interests: extractive metallurgy, hydrometallurgy. E-mail: yvera@cetem.gov.br.

The rare earth element samarium is mainly used to make permanent magnets of Sm_2Co_{17}, and although samarium magnets are being replaced by less expensive neodymium alloy magnets, they are still valuable due to their superior performance at high temperatures. In turn, europium is employed to make various red phosphors for color monitors and display panels and fluorescent lamps. Its luminescence is also valuable in medical, surgical and biochemical applications [1].

The objectives of this study were to investigate the continuous separation of the REEs europium and samarium using organophosphorus acids. In particular, we determined the number of stages and the A/O ratio for continuous solvent extraction of Eu/Sm based on extraction isotherms and application of the McCabe-Thiele method. The continuous solvent extraction of Sm/Eu was carried out in semi-pilot scale with and without the addition of lactic acid in the extraction medium.

2. Material and Methods

2.1 Chemical Reagents

The REE feed solution was prepared from digestion with concentrated HCl PA (12 mol L^{-1}) of the oxides of the respective elements. The concentrations of the REEs in the feed liquor, expressed as oxide, were 15.34 g L^{-1} of Sm_2O_3 and 11.32 g L^{-1} of Eu_2O_3. The elements Sm and Eu present in the chloride medium mainly consisted of free ions (M^{3+}) and chloride complexes, with a smaller quantity of 1 or 2 chlorine atoms (MCl^{-2}, MCl^{2-}). The REE oxides were acquired from Pacific Industrial Development Corporation. The pH of the feed solution was adjusted with solid NaOH PA. The reagents (concentrated HCl, solid NaOH, and lactic acid) were purchased from Vetec Química/Sigma-Aldrich.

The extractants used were P507 (2-ethylhexyl phosphonic acid mono-2-ethylhexyl ester) and D2EHPA (di-(2-ethylhexyl) phosphoric acid), supplied by Aodachem (China). Commercial kerosene, supplied by Ypiranga (Brazil), was used as diluent.

2.2 Batch and Bench-Scale Solvent Extraction Tests to Obtain the Extraction Isotherm

Batch and bench-scale extraction experiments were carried out to construct the extraction isotherm by varying the volumetric ratio between the aqueous and organic phases (A/O) between 0.125 and 10. The REE and extractant feed solutions were stirred for 30 minutes at 250 rpm in separation funnels. The phase disaggregation time was 30 minutes and the tests were performed at room temperature. The P507 concentration was 0.3 mol L^{-1} (10% v/v), and when using the mixture of P507 and D2EHPA, the respective concentrations were 0.24 mol L^{-1} (8% v/v) and 0.06 mol L^{-1} (2% v/v).

2.3 Continuous Solvent Extraction Tests

The continuous solvent extraction experiments were carried out with countercurrent using mixer settlers arranged in series (mixer volume of 240 mL and decanter volume of 370 mL).

The continuous solvent extraction tests of Sm and Eu were performed under the following conditions:

1) Extractant P507 10% (v/v) and Sm/Eu liquor without lactic acid at pH 2.0.
2) Extractant P507 10% (v/v) and Sm/Eu liquor containing 0.3 mol L^{-1} of lactic acid at pH 3.0.
3) Extractants P507 8% (v/v) and D2EHPA 2% (v/v) and Sm/Eu liquor containing 0.3 mol L^{-1} of lactic acid at pH 3.0.

2.4 Chemical Analyses and Calculation of Parameters

The concentrations of samarium and europium in aqueous solution were determined by UV-Vis spectrophotometry. The absorbance was read at wavelengths of 401 nm and 394 nm for Sm and Eu, respectively.

The concentrations of Sm and Eu in the aqueous phase in each extraction cell were used to determine the

concentration of the organic phase in each cell (Eq. (1)) and the quantity extracted of each element in each cell (Eq. (2)). Besides this, three other parameters were calculated: separation factor (βEu/Sm) and recovery percentages of Sm and Eu in the organic and refined extract (%REC) (Eqs. (3)-(6)).

$$[M]_{N\,(org)} = {}^{A}/_{O}\,x\,\left([M]_{N+1\,(aq)} - [M]_{N\,(aq)}\right) + [M]_{N-1\,(org)} \quad (1)$$

$$\%E = \frac{[M]_{feed} - [M]_{N\,(aq)}}{[M]_{feed}} \quad (2)$$

$$D = \frac{[M]_{extract}}{[M]_{raffinate}} \quad (3)$$

$$\beta_{M1/M2} = \frac{D_1}{D_2} \quad (4)$$

$$\%\ REC = \frac{[Q_m]_{extract}}{[Q_m]_{feed}} \times 100 \quad (5)$$

$$\%\ REC = \frac{[Q_m]_{raffinate}}{[Q_m]_{feed}} \times 100 \quad (6)$$

In those equations, $[M]_{N(org)}$ (g L^{-1}) and $[M]_{N\,(aq)}$ (g L^{-1}) denote the concentrations of each REE at the outlet of cell N in the organic and aqueous phases, respectively; and $[Qm]_{extract}$ (mg min^{-1}) and $[Qm]_{raffinate}$ (mg min^{-1}) represent the mass flows of each element at the outlet of the extraction circuit in the organic and aqueous phases, respectively.

3. Results and Discussion

3.1 Extraction Isotherms

The McCabe-Thiele diagrams of the extraction of Sm and Eu from an aqueous solution of Sm/Eu at pH 2.0 without adding lactic acid are shown in Fig. 1. According to the McCabe-Thiele method, after 7 counter current stages using an A/O ratio of 1/10, the corresponding extraction percentages of Sm and Eu were 66% and 84%.

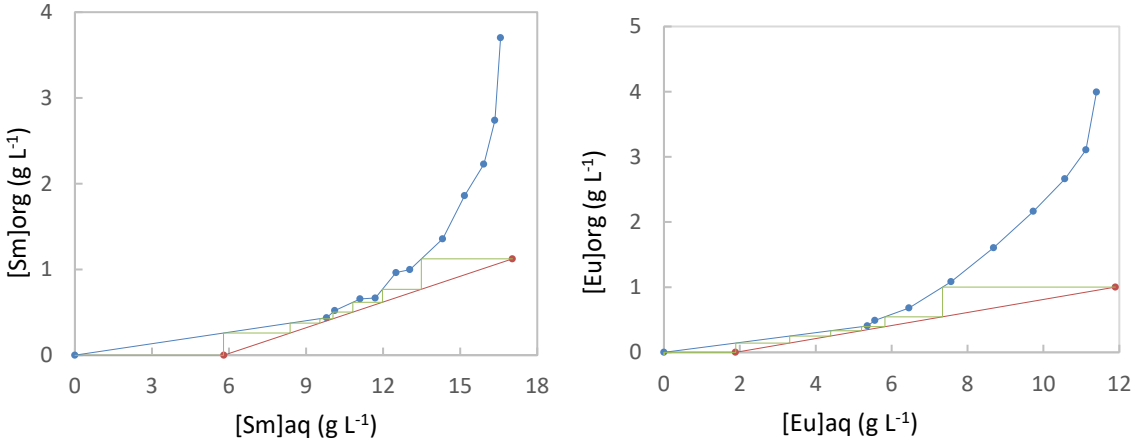

Fig. 1 Extraction isotherms of Sm and Eu obtained in batch solvent extraction tests: Extractant P507 10% (v/v); feed Sm_2O_3 15.34 g L^{-1} and Eu_2O_3 11.32 g L^{-1}; pH 2.0; HLac 0.0 mol L^{-1}.

The McCabe-Thiele diagrams of the extraction of Sm and Eu from the aqueous solution of Sm/Eu containing 0.3 mol L^{-1} of lactic acid at pH 3.0 show that 11 stages were necessary with an A/O ratio of 3/10 to extract 90% and 99% of Sm and Eu, respectively (Fig. 2). The extraction of the REEs increased in the presence of lactic acid. Although the number of stages increased from 7 (without lactic acid) to 11 (with lactic acid), there was an increase in the A/O ratio from 0.1 to 0.3. This three-fold increase means lower extractant cost.

Lactic acid (HLac) is a weak acid that partially ionizes in water, and its pKa is 3.86. At the pH value of the feed solution (pH 3.0), lactic acid is 13.6% ionized in the form of lactate ions (Lac^-) (Eq. (7)). The organophosphorus acids (H_2A_2) hydrogen ions with the ions of the REEs present in the aqueous phase (Eq. (8)). In aqueous solution, the lactate ions combine with the hydrogen ions released by the organic extractant (Eq.

(9)). Thus, the lactate ions neutralize part of the H+ ions and prevent a drastic increase in the acidity of the aqueous solution, enhancing the separation of the REEs.

$$HLac_{(a)} = Lac^{-}_{(a)} + H^{+}_{(a)} \quad (7)$$

$$REE^{3+}_{(a)} + 3\,H_2A_{2\,(o)} = REE(HA_2)_{3\,(o)} + 3\,H^{+}_{(a)} \quad (8)$$

$$H^{+}_{(a)} + Lac^{-}_{(a)} = HLac_{(a)} \quad (9)$$

3.2 Continuous Solvent Extraction

Continuous Sm/Eu extraction was carried out in the absence and presence of lactic acid (Figs. 3 and 4). The number of stages and A/O ratio were determined previously based on the McCabe-Thiele diagrams (Figs. 1 and 2).

The continuous solvent extraction test conditions and the results are presented in Tables 1 and 2.

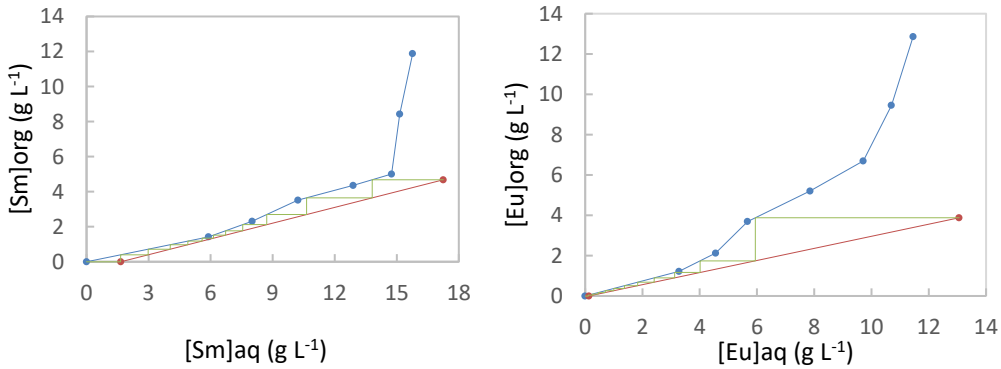

Fig. 2 Extraction isotherms of Sm and Eu obtained in batch solvent extraction tests: Extractant P507 10% (v/v); feed Sm_2O_3 15.34 g L^{-1} and Eu_2O_3 11.32 g L^{-1}; pH 3.0; HLac 0.3 mol L^{-1}.

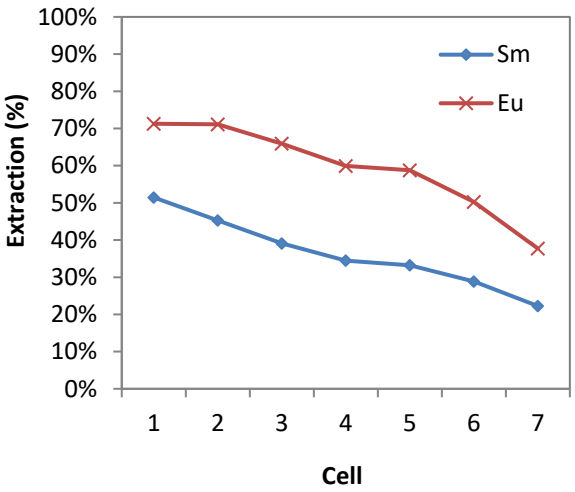

Fig. 3 Cumulative extraction of Sm and Eu obtained in the countercurrent solvent extraction circuit: Extractant P507 10% (v/v); feed Sm_2O_3 15.34 g L^{-1} and Eu_2O_3 11.32 g L^{-1}; pH 2.0; [HLac] 0.0 mol L^{-1}; A/O ratio 1:10.

Despite the higher extraction of Eu with addition of lactic acid (0.3 mol L^{-1}), the element was not completely extracted. Since the objective was to extract 100% of the Eu, a new continuous solvent extraction test was conducted using a mixture of P507 and D2EHPA as extractant. D2EHPA has greater affinity for the REEs than does P507, which increases their extraction. The number of stages, A/O ratio, concentration of HLac, and pH of the feed solution were the same as in the test with P507 at 10% (v/v) in the presence of lactic acid (Fig. 5).

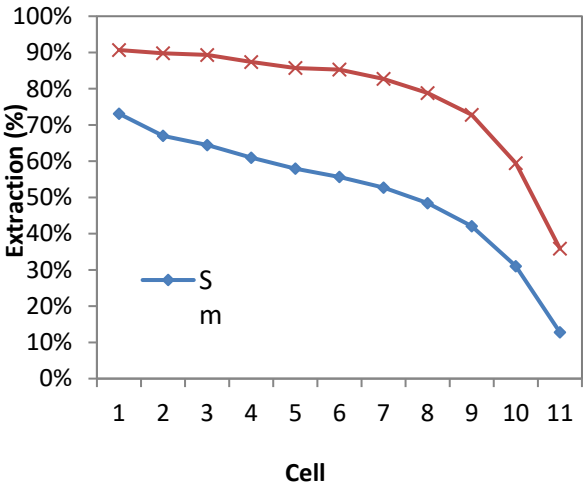

Fig. 4 Cumulative extraction of Sm and Eu obtained in the countercurrent solvent extraction circuit: Extractant P507 10% (v/v); feed Sm_2O_3 15.34 g L^{-1} and Eu_2O_3 11.32 g L^{-1}; pH 3.0, [HLac] 0.3 mol L^{-1}; A/O ratio 3:10.

Table 1 Conditions and results of the continuous solvent extraction tests of Sm and Eu.

Conditions						Results			
Test	Extractant (%)	pH	Number of Stages	A/O	[HLac] (mol L^{-1})	Extraction (%)	Eu/Sm	Extract Composition (g L^{-1})	Extract Purity (%)
1	P507 10%	2.0	7	0.13	0.0	Sm: 51.5 Eu: 71.3	2.48	Sm: 1.16 Eu: 1.14 Total: 2.3	Sm: 50.4 Eu: 49.6
2	P507 10%	3.0	11	0.31	0.3	Sm: 73.1 Eu: 90.7	3.58	Sm: 4.13 Eu: 3.89 Total: 8.01	Sm: 51.5 Eu: 48.5
3	P507 8% + D2EHPA 2%	3.0	11	0.29	0.3	Sm: 94.4 Eu: 95.8	1.36	Sm: 4.90 Eu: 3.65 Total: 8.54	Sm: 57.3 Eu: 42.7

Table 2 Results of the continuous solvent extraction tests of Sm and Eu.

	Results					
Test	Mass Flow of Extract (mg min^{-1})	Recovery in Extract (%)	Composition of Raffinate (g L^{-1})	Purity in Raffinate (%)	Mass Flow of Raffinate (mg min^{-1})	Recovery in Raffinate (%)
1	Sm: 115.8 Eu: 113.9 Total: 229.7	Sm: 57.6 Eu: 76.1	Sm: 8.52 Eu: 3.58 Total: 12.1	Sm: 70.4 Eu: 29.6	Sm: 85.2 Eu: 35.8 Total: 121.0	Sm: 42.4 Eu: 23.9
2	Sm: 165.1 Eu: 155.5 Total: 320.6	Sm: 73.7 Eu: 90.9	Sm: 4.90 Eu: 1.29 Total: 6.19	Sm: 79.2 Eu: 20.8	Sm: 58.8 Eu: 15.5 Total: 74.3	Sm: 26.3 Eu: 9.1
3	Sm: 195.9 Eu: 145.8 Total: 341.7	Sm: 95.3 Eu: 96.5	Sm: 0.55 Eu: 1.00 Total: 1.55	Sm: 64.4 Eu: 35.6	Sm: 9.7 Eu: 5.3 Total: 14.9	Sm: 4.7 Eu: 3.5

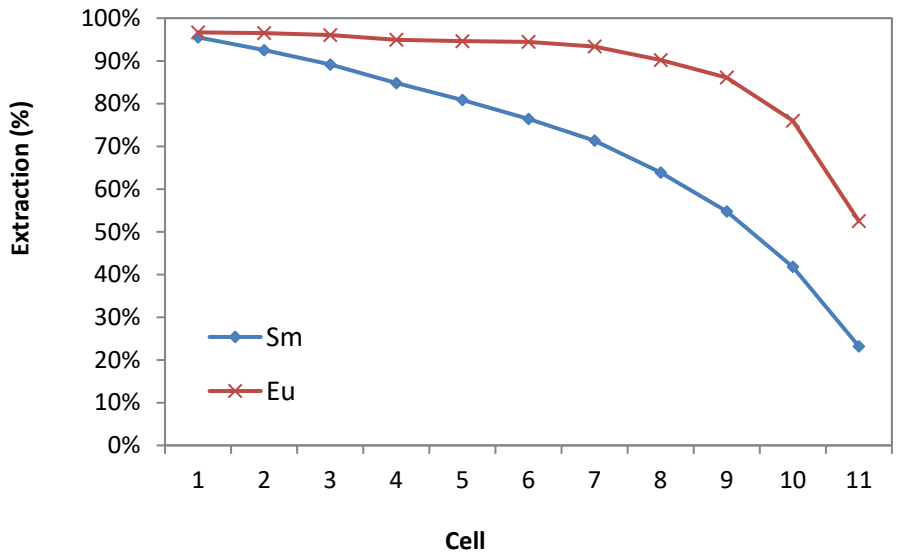

Fig. 5 Cumulative extraction of Sm and obtained in the counter current solvent extraction circuit: Extractant P507 8% (v/v) + D2EHPA 2% (v/v); feed Sm_2O_3 15.34 g L^{-1} and Eu_2O_3 11.32 g L^{-1}; pH 3.0; [HLac] 0.3 mol L^{-1}; A/O ratio 3:10.

The extraction preference of the REEs in this case was Eu > Sm. The cumulative extraction of the lanthanides increased with the addition of lactic acid to the feed solution. The cumulative extraction of Eu increased from 71.0% to 90.7% and that of Sm rose from 51.0% to 73.1% when the lactic acid concentration increased from 0 to 0.3 mol L^{-1}. The Eu/Sm separation factor increased from 2.48 to 3.58

when adding lactic acid to the extractant system. The use of the mixture of extractants D2EHPA (2%) and P507 (8%) increased the extraction rates of Sm and Eu to 94.4% and 95.8%, respectively, but considerably reduced the extraction selectivity by diminishing the Eu/Sm separation factor to 1.36.

The aqueous feed solution used in the SX tests was composed of 57.5% Sm_2O_3 and 42.5% Eu_2O_3. The objective of these tests was to separate the elements Sm and Eu so as to concentrate the Eu as much as possible in the aqueous phase.

Of the three tests conducted, that using P507 10% and HLac 0.3 mol L^{-1} (Test 2, Tables 1 and 2) produced the organic extract with highest concentration of Eu (3.89 g L^{-1}) and obtained the highest mass flow of Eu in the organic extract (155.5 mg min^{-1}). The organic extract with the greatest purity of Eu was obtained in the test without addition of HLac (Test 1), but the concentration of Eu obtained in this test was approximately 3 times lower than that obtained in Test 2. The greatest recovery of Eu in the organic extract was obtained in Test 3 (96.5%).

The SX test using P507 (10%) without adding lactic acid (Test 1, Tab. 1 and 2) produced raffinate with the highest concentration of Sm (8.52 g L^{-1}), greatest mass flow of Sm in the raffinate (85.2 mg min^{-1}) and highest recovery of Sm in the raffinate (42.4%). The greatest purity of Sm in the raffinate was obtained in Test 2 (79.2%) (Tables 1 and 2).

Since in any test conducted it will be necessary to wash the organic phase after the extraction step to remove the Sm present in the extract, the objective should be to remove as much of the Eu as possible from the feed solution so that it is not lost in the raffinate. Therefore, we believe that Test 3 is more suitable to achieve the objectives of separating Eu and Sm, despite its lower selectivity.

4. Conclusion

This study investigated the continuous solvent extraction of the REEs europium and samarium using organophosphorus extractants. The number of stages and A/O ratio of the continuous solvent extraction of Eu and Sm were determined based on extraction isotherms and application of the McCabe-Thiele method. The maximum extraction levels of Eu and Sm were 66% and 84%, respectively, when using 7 extraction stages and an A/O ratio of 0.1. When adding lactic acid, the maximum extraction levels of Sm and Eu were 90% and 99%, respectively, when using 11 stages and an A/O ratio of 0.3. Continuous solvent extraction of Sm/Eu was carried out in a semi-pilot scale with and without the addition of lactic acid in the extraction medium. Under the conditions studied, the best results were obtained using a mixture of P507 (8%) and D2EHPA (2%) with addition of lactic acid in the extractant system. Under these conditions, 96.5% of the europium in the organic phase was recovered. In future experiments we will analyze the washing of the loaded organic extract produced in the extraction step.

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Training Architecture Sector in the Context of Globalization and International Integration: Issues and Solutions

Truong Thi Thanh Truc

Department of Architecture, University of Architecture Hochiminh City, Vietnam

Abstract: Globalization is taking place in the wake of the scientific and technological boom. This has led to the need for knowledge innovation that no other country can stand outside, especially Vietnam. Therefore, the training in architecture also needs to be changed to adapt to the development practices. This paper aims to emphasize the importance of "international integration" in the process of "fundamental and comprehensive innovation" in training architecture. Through the process of understanding the training status of the architecture industry in Vietnam, in order to see clearly the limitations that exist in the teaching work to propose solutions to overcome and propose renewal on the content. such as: Program; Training mode; Examination and evaluation of training results and vocational activities after graduation.

Key words: globalization, training architecture, renew

1. Introduction

Architecture is an important branch because it is directly linked to social life and attached to the culture and customs of each nation. Therefore, training architects who are both professional and able to meet the actual situation of social development is an extremely important issue of countries in general and Vietnam in particular. Personally, when I studied the university training program according to the list of 35 schools including construction and architecture industry in Vietnam (Vietnam), there are currently 21 architecture training institutions. In which the places are considered to provide the main source of architects including Hanoi University of Architecture, Ho Chi Minh City University of Architecture, Hanoi University of Construction. There are also Hue University, other open and private universities.

Corresponding author: Truong Thi Thanh Truc, Ph.D.; research areas/interests: architecture and urban planning. E-mail: truc.truongthithanh@uah.edu.vn.

However, many Vietnamese architecture students and architects who have been trained from these facilities have won many prestigious awards around the world. However, it must be admitted that to enter the integration, Vietnamese architects have shown weaknesses on the "home ground" because of the lack of professionalism and specificity. So what is the current situation and problems in the training of architects in the current educational program in Vietnam?

In my opinion, the following specific issues should be considered:

- Regarding the content of the training program for architecture
- About architectural training method.
- Regarding the inspection and evaluation of architectural training results
- Influence from the limitations of the old architectural training method on the performance capacity of students in the career process.

2. Material and Methods

2.1 For the Content of Training Programs in Architecture

Most of the architecture training programs of Vietnam have been converted to the form of studying credits (with the total accumulated credits of about 160 credits, within 10 semesters). But most of the school is still oriented towards conducting research with practice in the direction of synthesis, not implementing specialized sub-sectors. Therefore, the applicability is limited. Although the content and training program is still consistent with the actual situation of development of the field of architecture in Vietnam today. However, in the future, in order to integrate with the international environment, it is certain that this training direction will not be able to meet the goal of training "high-quality architects" according to the development requirements of the world due to its structure. The curriculum structure with architecture training curriculum is not really appropriate. For example, although studying a specific major, architecture students still have to meet the general training content (36 credits, accounting for 22.5%, including political theory and national education). room accounted for 9-10%) like students of other disciplines, along with quite a large amount of architectural knowledge (116 credits, accounting for 72.5%, including: Basic knowledge of the block architecture is 12 credits — 7.50%; Architectural knowledge is 90 credits — 56.25%; Supplementary knowledge, apprenticeship consists of 4 credits — 2.50%; the project of graduating 10 credits — 6.25%) and the Knowledge Block in which students are able to choose the content they want to study at a too low rate (only 8 credits, accounting for 5%).

On the other hand, architecture is an industry that requires employees not only to have specialized knowledge but also to have general knowledge from other fields such as economy, society, culture, arts, etc. But because these contents are not required in the curriculum, most architecture students have not taken the time to supplement other areas of knowledge. This leads to a lack of artistic sense, a lack of emotion and a lack of creativity in design activities.

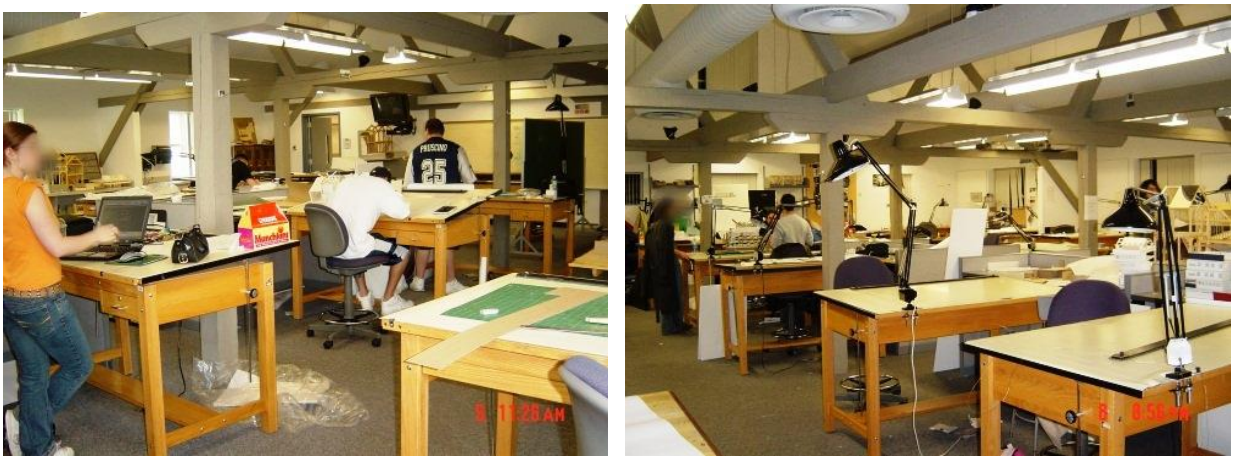
2.2 For Training Methods in Architecture

Considering this issue, the concept of training architects at university level in Vietnam compared to other countries in the world has been different from the way of enrollment. Countries around the world often evaluate technology and art equally, these are two necessary and sufficient factors for a person to choose to study architecture. In fact, in Vietnam, some schools with major in architecture training have placed a heavy role in drawing so doubling the score of gifted subjects when calculating input scores. Therefore, most students who want to study architecture must practice drawing two to three years before taking the University entrance exam. On the other hand, some schools will not calculate drawing subjects, of which drawing is only a factor for admission.

Comparison of training methods Architects in Vietnam also noticed the difference compared to many other countries in the world. In the first two years, universities in Vietnam teach basic subjects, mainly equip students with the skills of expressing architectural drawings. So most of the students of Architecture in Vietnam will conceive of expressing the design ideas in an "eye-catching" and "impressive" way without paying attention to the core of construction techniques and feasibility behind each construction. In most other countries, students are given priority in equipping with methods and ways of thinking, drawing skills are only considered as the tools in which to convey the content of the design. In other countries, architecture students often show design projects through many different ways of expressing, not stopping at showing drawings on paper like in Vietnam. Through the variety of expressions, this will help architectural students easily

express ideas, easily visualize how their designs will be formed in reality (Fig. 1).

The method of training architecture in Vietnam today is still in a popular way for a long time: The University assigns students a hypothetical topic that has been prepared, from content to details. After that, students meet with lecturers to present ideas (mainly paper sketches) according to the class schedule (from 6 to 9 weeks). Finally, students show the whole project from 4 to 5 sheets of A1 paper, printed in color (very costly) for the teacher to grade in 5-10 minutes without the students' explanation. This has led the faculty to impose subjective ideas in student creations. Meanwhile, the topics that architecture students in other countries, they are often real topics, the university also organizes students to practice, build experiments from the ideas of furniture. subject project. Vietnamese students who want to have the opportunity to practice often have to look for themselves through part-time jobs in Architecture Design workshops. This gives Vietnamese architecture students the opportunity to get in touch with reality. But in my opinion, this is only at the level of "draftsman" but not training the mind (Fig. 2).



Architecture students present their projects in a separate studio with different expressions.

Fig. 1 Time to present the project in a studio of Savannah College of Art and Design, USA.

The topics that Architecture students study in assigned countries are often real-life subjects.

Fig. 2 The idea of a student's project of Savannah College of Art and Design - USA to build experiments.

Besides, with the current training method of Vietnamese architecture industry, there is absolutely no attention to training students' skills and soft skills (writing, presentation, searching and exploitation skills), use documents, communicate in English, work in groups, ...). Especially specialized English subject is

still not considered in the training program. Therefore, the ability of students to access new knowledge about careers from foreign countries is not much and architecture students and architects also lack confidence in using foreign languages when working, cooperating, learning exchange, ... with foreign countries.

An equally important element in the mode of architecture training is the teaching staff. Architectural lecturers in Vietnam can now be divided into two groups: Firstly, those who have a lot of experience due to the opportunity to participate in designing and constructing real works. These lecturers have a lot of valuable experience to convey to students, but on the other hand, they are often very busy so the time to support and close with students is not much; Second, those who teach merely, are very knowledgeable about theoretical issues, but lack experience in practicing. Therefore they cannot guide students deeply about practicality.

Regarding training methods, it is also necessary to mention the conditions for reviewing the output of architecture students in Vietnam is still relatively easy (each year nearly 90-95% of students are eligible to graduate). Therefore, making competition in study is very low, not creating the impetus for students to strive for learning. They have to find their own motivation without much pressure from the environment in university. In other countries, Architecture students must make great personal efforts to complete the Bachelor of Science program. As a result, the quality of output is guaranteed and students feel confident and withstand the pressure of responsibility when practicing after graduation.

2.3 Regarding the Inspection and Evaluation of Architectural Training Results

There is no synchronization between innovating teaching methods with assessing and measuring academic achievement of architecture students, as well as not yet applying widely modern forms and teaching methods. Therefore, it has not created a breakthrough in innovation and evaluation.

The assessment of students' knowledge and skills has not yet been conducted due to classroom and extra-curricular activities.

Not attaching importance to checking the reading ability as well as the self-study ability, the ability to apply the learned knowledge into reality of students.

2.4 Influence From the Limitations of the Previous Architectural Training Method on Student Performance in Professional Activities

Regarding knowledge, especially architectural knowledge has not been fully updated with scientific and technological achievements of advanced countries. Since then, professional capacity has not kept up with the development needs of the society; Lacking knowledge of logical thinking in creativity, social knowledge and lack of practical experience, it is difficult to adapt immediately to practical work after graduation.

In terms of skills, architecture students are still limited such as: skills of exploiting information and materials (searching, reading books, etc.), applying knowledge into practice, writing and presenting ideas, doing teamwork, ... therefore, it is difficult for architecture students to maximize their capabilities at work. Especially communication skills in English are limited, so it is difficult to integrate and participate in international cooperation.

In terms of attitude, due to the limitations of the program content and training methods, architectural students lack self-awareness and initiative, lack of cooperation, lack of sensitivity, flexibility and difficulty adapting, ... Therefore students have not met the requirements of employers from domestic and abroad.

The above limitations are the cause of the situation: about 30% of architecture graduates have the ability to compose and graduate in the right field of study. In addition, more and more architects and design companies from abroad come to work in Vietnam,

causing competition with local companies. They have abundant financial resources, capacity and reputation to practice. Therefore, these international design consultancy organizations have affirmed their position in Vietnam and spent most (~80%) of large projects in Vietnam [1].

Compared with other countries in the world and in the region, we can easily see that the current architecture training in Vietnam is very worrying because it cannot compete or enter the international arena. In view of the current training of architects in Vietnam towards international integration, three main issues can emerge:

Firstly, the relationship between training and practicing. If previous training activities were one-way knowledge transfer, from training institutions to learners. Today architecture training universities are well aware of the two-way effect of having to teach according to the needs of society. In which, reducing the theoretical content and increasing practical content is extremely necessary. Note, practical experience can be put into training to make learning content closer to life, but on the other hand can also inhibit the creativity of architectural students.

Second, the task of architectural training today has become more difficult as society requires more multidimensional architectural design methods. In addition to the classic design roadmap (from the function to the structure, then the form is the intrinsic elements of architecture trusc), the new training program for the architecture industry needs more starting points as problems, periphery of architecture (structure, location, society, ecology, psychology... moving from function, technology, economics to humanistic approaches) to adjust the design roadmap to suit the Require innovation and international integration. This forces architectural training process to change accordingly.

Thirdly, it is necessary to balance the relationship between "globalization" and "localization", between "internationalization" and "localization" so that the architecture industry integrates without being dissolved in the process of operation, career activity. Architects can practice in many countries, with different cultures and can participate in solving local problems locally. They must be equipped with not only specialized knowledge but also a complete range of other personal skills.

3. Results and Discussion

3.1 Some Innovative Solutions in Training Architecture in the Direction of International Integration

From the objective and subjective practice mentioned above, in order to prepare for the training of architecture industry capable of integrating with other countries in the world, it is necessary to innovate from thought to action. Because architecture is a unique industry and the goal set for architecture training in Vietnam is "Innovation and integration must still retain the traditional characteristics of Vietnam. At the same time, training closely follows the common standards of the world". Therefore, there should be specific solutions for architectural training as follows.

3.2 For the Content of Training Programs

The university continues to equip students with comprehensive knowledge so that upon graduation, students can adapt to all conditions and jobs according to the broad needs of society. In addition, the university needs to quickly develop training programs for a number of specialized majors meeting international standards, aiming at the goal of future integration. For example, the architecture industry is developing a "High-quality training program" in which all content-innovated subjects revolve around the two most important goals, which is to improve creativity and professionalism.

The conduct of rebuilding training programs, compiling textbooks, textbooks for architecture majors should consult and select experiences from developed countries. This method of reference will help reduce

difficulties in finding content for training programs, saving time, on the right track and according to the development requirements of the world.

The development of training programs, content development, detailed outline of modules of advanced programs, high quality training programs, should be carried out comprehensively and closely. At the same time, there is the participation of lecturers who are directly teaching, collecting comments from alumni, employers "representatives and especially experts" evaluation, in addition to training institutions (domestic and international), who are knowledgeable in their field of expertise.

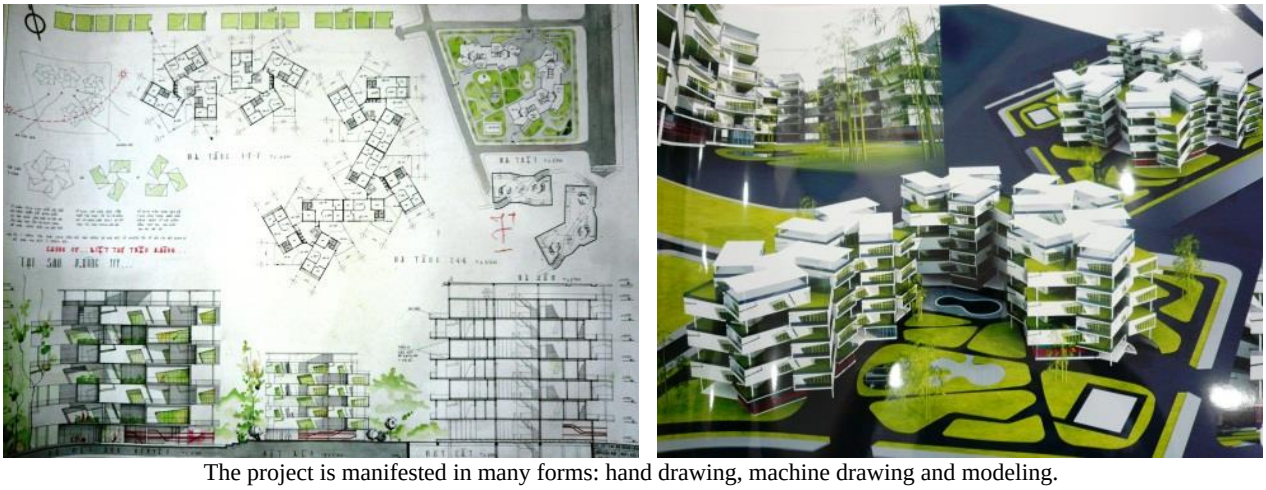
3.3 For Training Methods

The first is to improve the quality of the input with a consistent and proper assessment of drawing among architectural training institutions across the country.

The proposal of the basic training method is to use a variety of advanced teaching methods and technologies of the world but according to the principle of "taking learners as the center and the market demand in the trend of globalization as training objectives".

Innovating in the direction of self-study, improving creative capacity: encourage students to present design projects in many different forms and materials and give students a description of their research process. Minimize theoretical hours to allow students more time to study and practice. The University proactively organizes for students to experience and apply specialized knowledge in practice such as: making topics close to reality, connecting with businesses and organizations to give students many opportunities. practice, invite master architects to exchange experiences, organize more specialized seminars and conferences, and especially need to promote the dialogue between teachers and students in teaching and learning. The workshop-specific training model at Hanoi Architectural University is also very suitable for promoting practical architectural design and practical applications. Therefore, it should be replicated for specialized training institutions for architecture.

Enhancing the training of personal and soft skills for architecture students so as to meet the specific requirements of the output standards such as: Communicating all technical, spatial, and ideas aspects design through diverse forms of expression (hand-drawing and machine-drawing, modeling, ...); (Fig. 3) Clearly communicating fluently in writing and presenting ideas and steps for implementation; Proactive and autonomy in the research process as well as the completion of design projects thanks to the ability to integrate multi-faceted knowledge (about the design requirements of the type of works, the contextual relationships, about environment, technical



The project is manifested in many forms: hand drawing, machine drawing and modeling.

Fig. 3 Design project of HCMC architecture students.

system, historical, cultural, social knowledge, law, ...); Architecture training institutions should focus on training quality rather than the number of graduates. In essence, "Integration Training Architectural Problem" is a financial problem. Only when there is abundant financial resources, the university has enough potential to develop and compete. Therefore, training institutions in architecture need to have plans to collect tuition in accordance with their training activities.

Finally, the standardization of the output quality must follow the international standard, then architecture training in Vietnam will have the opportunity to integrate. In the research for the advanced training program of the University of Architecture of Ho Chi Minh City. HCM, the results were quite surprising when it was discovered that: More than 60% of students do not have a spirit of striving for learning. Because the output was easy, even though students had to repeat and retake the exams, the students graduated. The consequence of this mindset is that students have lost the opportunity to train themselves to improve their work performance, which is also the cause for losing many job opportunities during the period of international integration.

3.4 Regarding the Inspection and Evaluation of Architectural Training Results

Currently, the University of Architecture City. Ho Chi Minh City is complying with "Regulations on formal university training under the credit system". Therefore, the evaluation of training results shall comply with the current regulations of the Ministry of Education and Training on organizing examinations, examination and evaluation and recognition of results. However, the upcoming integration process will implement the certification of ASEAN architects, architecture universities must join the international accreditation system. Therefore, it is necessary to consolidate the structure, content of the curriculum, facilities and the form of teaching and learning. Then perform periodic accreditation to ensure the maintenance of training quality. Finally, it is required to register with one of the world's prestigious testing organizations to be assessed and recognized to meet international standards.

3.5 For Architectural Career After Graduation

Graduation — what will learners do? What are the qualities that an architect wants to assert a reputation for expertise? Those are the necessary permanent questions for the training results.

Although there are differences in the content and way of teaching, but the schools of architecture have a common orientation is to equip career knowledge for architecture students to become an architect who can take responsibility for the law. The project will be chaired by the designer. However, after graduation, people who are trained in architecture can also participate in the labor market in many different fields such as design, planning, conservation-restoration, management, competition, public, real estate, research-training, visual arts, graphic design, ... In the above areas, they often work in groups, with a distinction of the head — the leader and the members in charge, different levels of work. Self-shaping each student's way of training and the right teaching goals in the training of training institutions, this will be an authentic and valuable evidence of the results of teaching and learning. Since then answering the question of architects training in Vietnam can meet the diverse requirements of the labor market or not?

At the same time encourage the process of learning and career development after graduation of the architect. Encourage them to supplement as much as possible knowledge in other specialized fields such as economics, agriculture, engineering, politics, psychology, ... The University needs to continue supporting students after graduation, through further professional training. The university must become an academic place that students want to visit often, even after they graduate.

Architectural associations should also be established and these associations will be an organization that not only manages the professional activities of architects but also helps them. Especially the young architects have the favorable environment to operate more professionally. The Architect Association is also the venue to organize and encourage architects to participate in career forums, domestic and international competitions, in order to find and create generations of qualified architects to integration.

4. Conclusion

In this article, I would like to emphasize the special importance of "international integration" in the process of "fundamental and comprehensive innovation" in architecture training. Because when Vietnam joined the WTO, the human resources in architecture must ensure the quality and efficiency of global competition and international integration. Therefore, it is necessary to take advanced international experiences, standards and values as a basis and destination for architectural training in Vietnam. Therefore, it is necessary to innovate comprehensively to train generations of Vietnamese architects to master living and working skills on a global scale. The paper goes from understanding the current status of architecture training in Vietnam in order to clearly identify the limitations to offer remedial solutions, as well as propose a specific and comprehensive innovation including: content of the training program; mode of training; examination and evaluation of training results and vocational activities after graduation.

When looking directly at the situation of limitations of training architecture in Vietnam and making specific action plans to overcome. In order to integrate into the world, universities of architecture training must renovate the curriculum and teaching methods to adapt to the development, enhance the attraction and must build their own brand, every school. Since then, universities have done a good job as a training machine to create human resources operating in the field of architecture for the country, able to survive and compete in an era of globalization.

Innovation is not only the task of architecture training universities, but also the role of state management agencies in organizing professional activities. Legally, it is necessary to continue supplementing and completing legal provisions on architectural profession activities in the context of international integration. State management agencies, directly under the Ministry of Education and Training, need to change the way of thinking about management of architectural training activities, must have specific mechanisms for training specific industries.

The renovation of architecture training also needs to be done in sync with other training levels. For example, foreign languages must be universalized from primary level so that when going to university, students no longer have difficulty in using materials in foreign languages. If so, it is only the curriculum adding a handful of phrases specialized in architecture.

Particularly in training architects in Vietnam, the situation is still limited as mentioned above, but these problems can be completely overcome. It is important to be determined and united in the implementation of innovation in architecture training in Vietnam. From setting the right training goals, in line with the general trend in the world, as well as implementing innovation in the training process of universities to bringing the training system of architecture standards, according to international accreditation and accreditation. This will help architectural students in Vietnam soon have many opportunities to mature and change their position in the world in the near future.

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Application of New Water Meter Management Technologies Based on Financial Economic Feasibility Studies

Luiz Claudio Drumonda[1], and M. V. Penido[2]

1. Micrometering Department, Rio de Janeiro State Water Supply Company, Brazil

2. Doctorand, Federal University of Rio de Janeiro, Brazil

Abstract: Velocity water meter after a time of use create wear and begin to record lower consumption instead of the real. Water supplied and non-revenue represents a loss by sub-measurement and can significantly impact a water company's revenues. Identify worn meters in water system is an essential premise for maintaining proper control over billing. It requires a more technical and careful approach, based on the management of the micrometering criteria. Water meters may have different performances depending on the manufacturer and technology. With a laboratory analysis is possible to identify the point at which type of meter present highest sub-measurement. The present work aims to present a method of analysis that allows to identify worn meters in water system, based on a study of financial economic feasibility determine which customers apply velocity water meters, volumetric meters or electronics meters known as static meters.

Key words: sub-measurement, static meters, economic feasibility

1. Introduction

Many water supply companies have been investing in loss reduction and control programs looking for improve their indicators and also aiming to minimize the withdrawal of raw water from the environment. Improving the performance of water supply systems focused on losses reducing has positively impacted the operating and energy efficiency of water supply companies, resulting in expenses reduction with inputs such as chemicals, electricity and equipment maintenance. The water balance proposed by International Water Association - IWA, water losses is the difference between the supplied and uninvoiced water volumes, known as apparent losses, one cause is the sub-measurement it is the inaccuracy of water meters, because these are mechanical devices that since their manufacturing have difficulty in measuring the volume effectively delivered, principally in indirect supply, with water reservoir. Water tank ball float valve reduces flow rates below water meter capacities. As the water meters wear out, the effects of the sub-measurement increase gradually. The sub-measurement percentage focuses on the entire volume. Clandestine connections, hacked water meters and failed registration also represent a portion of Apparent Loss, but will not be mentioned in the present study. As an ally in the fight against Apparent Loss, the noticed the arrival of new meters with different operating principles with emphasis in electronic, called as static meters. These devices although the costs above conventional meters can contribute to the reduction of Apparent Loss, needing a financial economic feasibility study before to take decision.

Corresponding author: Luiz Claudio Drumonda, Specialist Mechanical Engineer; research area/interest: water loss. E-mail: luizclaudio@cedae.com.br.

2. Technologies Available for Application in Micrometering — Cost × Benefit

As the well-known and widely used in Brazil and worldwide the velocity water meter, with recent Tests of Measurement Error Determination in accordance with ABNT 15538 [1], have provided reflections on volumetric water meter despite their vulnerability related to lock by particulate in suspension, its strength is the performance presented against velocity water meter, considering that in Brazil the indirect supply increase even more the effects of sub-measurement. It is available to use meters to measure with ultrasonic or electromagnetic technology with high performance batteries, providing accuracy and durability higher than conventional mechanical water meters. Another advantage of these meters is to have no moving parts, they are not susceptible to locking or wear, a fact that is frequent in turbine meters, limiting their permanence in the network in average a few years. On the one hand to have greater accuracy and durability, on the other hand the acquisition costs for application can make the investment unfeasible. The cost to purchase each type of meter has following the relation presented in Table 1.

3. Determination of Measurement Performance Index: Laboratory Studies

The methodology consists in obtaining the MPI, Measurement Performance Index (IDM in Portuguese), of samples of new and used water meters by manufacturer, type and capacity. For the present study, the tests were performed at the CEDAE, Rio de Janeiro state water supply company meter laboratory, certified by Inmetro, in accordance with ISO 17025, through CRL 1083.

The sampling plan was assembled containing different flow ranges in water meters removed from the water system. In accordance with ABNT NBR 15538 (Fig. 1) the MPI can be calculated by the following expression:

$$MPI = 100 + WE \quad (1)$$

where: WE = weighted error

Table 1 Average cost of meters by technology × performance.

Measuring Range	Technology	Cost*	Measurement performance index (MPI)
0-5 m³ / h	Velocity meter Class B	C1	93-96%
	Volumetric meter Class C	2 C1	98%
	Ultrasonic meter R 250	6 C1	99%

Fig. 1 CEDAE meter laboratory and MPI test bench.

The meter efficiency evaluation tests are based on a typical residence water supply consumption profile in Brazil, being obtained by the association between the consumption profile and the relative error presented by the water meter (WE), in the flow ranges detailed in Fig. 2.

Performing tests defined by the norm in n samples and adopting statistical criteria using the distribution t by Eq. (2) the obtained data are plotted in a graph as presented in Fig. 3.

$$\bar{x} - t_{(n\,-\,1.0\,.\,0.05)} \cdot \frac{s}{\sqrt{n}} \tag{2}$$

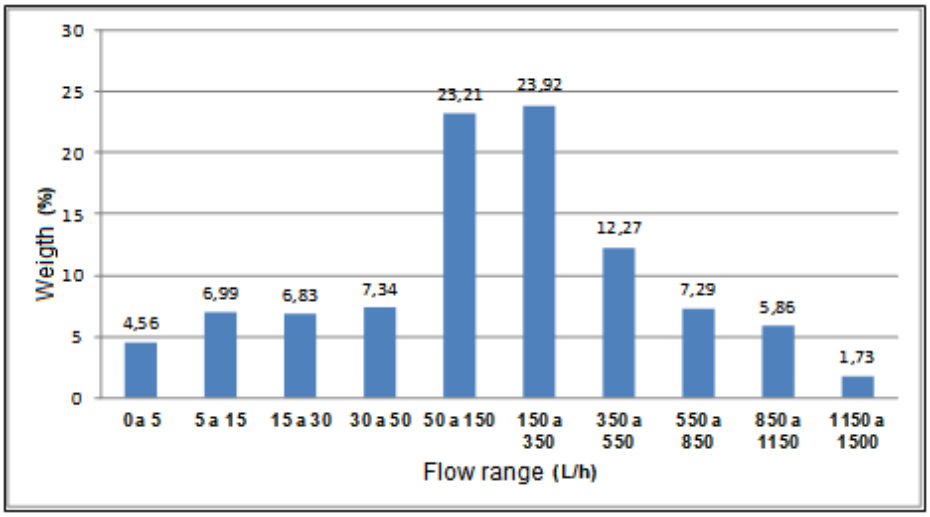

Fig. 2 Typical residence water supply consumption profile.

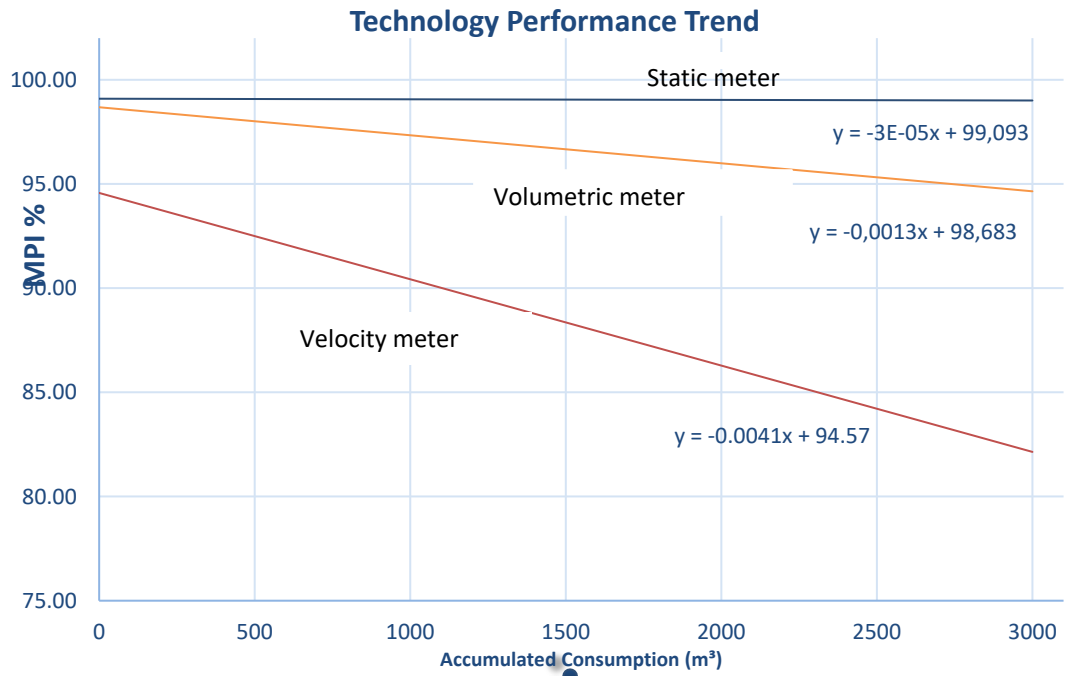

Fig. 3 Metrological performance trend – velocity water meters × volumetric meters × static meters.

Trend lines show that static meters do not wear and maintain the performance, but in the case of velocity meters and volumetric meters, the MPI decreases as the accumulated volume increases, proving that the wear is function of the turbine rotation number and not the installation time. The linear equations can be rewritten

as function of the reading (R) of each meter and the MPI. These equations represent the measurement effectiveness of the unijet velocity meter (x), volumetric meter (y) and ultrasonic meter (z). For example, the measurement effectiveness of the unijet velocity meters, mark (x) is:

$$MPI(R) = -0.0041 \,.\, R + 94.57 \quad (3)$$

4. Submitted Volume to a Meter in Use

The first step to choose which meter to replace is analyse the existing meter, is to identify which measurement performance the meter in use is presenting in the system line. Based on a known volume Kv it is possible to calculate the revenue recovery potential. The formula is:

$$Vs = Vm \left(\frac{MPIn}{MPIu} - 1\right) \quad (4)$$

where: Vs = submitted volume
Vm = average monthly volume
$MPIn$ = Measurement Performance Index new (%)
$MPIu$ = Measurement Performance Index use (%)

5. Calculation of Financial Recovery After a Meter Replace

If considering that a replacement of a worn-out water meter for a new meter will provide improved measurement and possibly in the billing. This improvement will be due to the wear of the meter in use, the quality of the new meter and the tariff value, following the tariff structure of each company. As an example, the CEDAE tariff structure in use in January 2017 showing in Table 2.

Table 2 Tariff structure - CEDAE Jan/2017.

Tariff	Band	Tariff value
T1	0 ~ 15 m³/month	$ 1.12
T2	> 15 ~ 30 m³/month	$ 2.47
T3	> 30 ~ 45 m³/month	$ 3.37
T4	> 45 ~ 60 m³/month	$ 6.75
T5	> 60 m³/month	$ 9.00

Therefore, obtain monthly recovered value Rv, after the changing of a water meter using the following expression:

$$Rv = Vs \,.\, T \quad (5)$$

Substituting the Eqs. (4) and (3) in the Eq. (5):

$$Rv = Vm \left(\frac{-0.0041 \,.Rn + 94.57}{-0.0041 \,.Ru + 94.57} - 1\right) .\, T \quad (6)$$

If the locality has the sewage collection, transportation and treatment service, the monthly amount recovered is multiplied by 2, so the expression will be:

$$Rv = Vm \left(\frac{-0.0041 \,.Rn + 94.57}{-0.0041 \,.Ru + 94.57} - 1\right) .\, T \,.\, 2 \quad (7)$$

where: Rn = Reading of the new meter
Ru = Reading of the used meter
T = Tariff value

Example 1: Replace of a meter in use for a new velocity meter.

In a customer with unijet velocity meter (x) in use with an average measured volume of 16 m³/month with a total reading of 850 m³, what will be the loss by sub-measurement recovered and what will be the monthly value recovered, if the meter is replaced by a new one with the same type of meter and from the same manufacturer?

Calculation of loss by recovered sub-measurement, using the Eq. (6), in this case without T:

$$Rv = 16 \left(\frac{-0.0041 \,.0 + 94.57}{-0.0041 \,.850 + 94.57} - 1\right) \quad (8)$$

$$Rv = 0.61 \text{ m³/month} \quad (9)$$

Or

$$Rv = 20.4 \text{ Liters/connection/day} \quad (10)$$

Calculation of monthly amount recovered value, considering the second tariff band using T2 = $ 2.47, substituting the Eq. (7):

$$Rv = 16 \left(\frac{-0.0041 \,.0 + 94.57}{-0.0041 \,.850 + 94.57} - 1\right) .\, 2.47 \,.\, 2 \quad (11)$$

$$Rv = \text{R\$ } 3.01\text{/month} \quad (12)$$

In this case replacing an old meter by a new one with the same type of meter, unijet velocity meter (x), from

the same manufacturer, will provide a recovered billing amount of R$ 3.01/month.

6. Financial Economic Feasibility Assessment

Project management best practices suggest previous economic feasibility studies. The essence of economic and financial valuation is to measure the return on a project in a manner comparable to other investments. The first step in carrying out the economic valuation is the cash flow assembly, the definition of the cash inflows and outflows during the desired measurement cycle. Valuation using cash flow will assist to the decision-making process. As an example, the following cash flow considering that the cost was around $25.40, being $15.88 the meter purchase and $9.52 the replacement labor cost:

To calculate the net present value NPV using the following equation:

$$NPV = \left(\frac{CF1}{(1+I)^1} + \frac{CF2}{(1+I)^2} + \cdots \frac{CFn}{(1+I)^n}\right) \quad (13)$$

The NPV of a substitution has the following result possibilities:

• Greater than zero: the replacement is economically viable;

• Equal to zero: no viable;

• Less than zero: not economically viable.

The cash flow from replaced old unijet meter by a new one with the same type of meter is showing in Fig. 4:

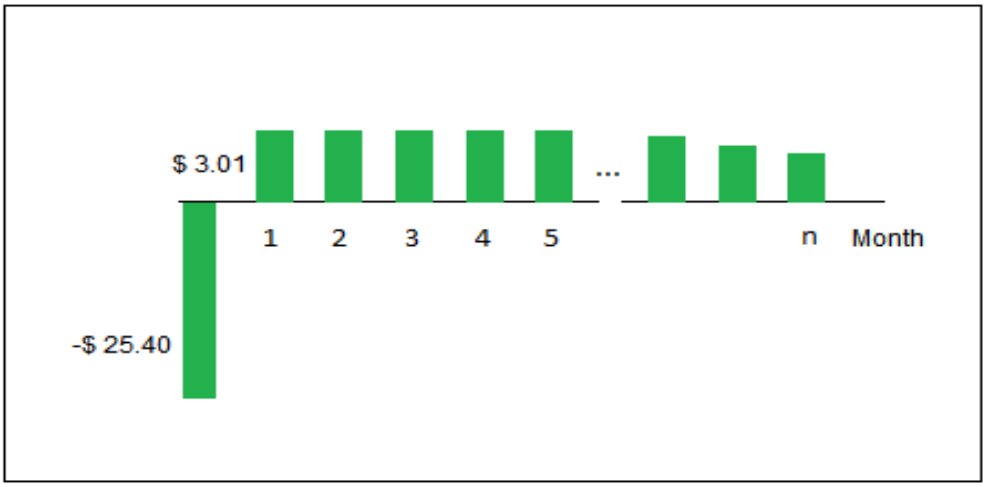

Fig. 4 Diagram cash flow from replaced meter.

Where: $25.40 was investment.

7. Feasibility Assessment of the velocity Meter

Therefore, to an estimated rate of 8% per year, Brazilian rate between 2017 and 2019, the NPV in 12 months of the example shown will be:

$$NPV = \$\,8.25 \quad (14)$$

Based on the previous example, is possible to see that the replace is economically viable, considering that the 12 months NPV will be positive and the payback investment of the $ 25.40 will occur in 9 months.

Example 2: Replace of a meter in use by a volumetric meter (y):

Adopting the same client with unijet velocity meter (x) in use with an average measured volume of 16 m³/month with a total reading of 850 m³, what will be the loss by sub-measurement recovered and what will be the monthly value recovered if it is replaced to a new volumetric water meter (y)?

Comment: Replacing the old meter by a volumetric meter of 1.5 m³/h class C, with Cost = 2C, considering:

$$MPI(R) = -0.0013\,.\,R + 98.6 \quad (15)$$

Calculation of loss by recovered sub-measurement, substituting the Eqs. (4) and (15) in the Eq. (5), the recovered value is, without T:

$$Rv = 16\left(\frac{-0.0013\ .\ 0+98.6}{-0.0013\ .\ 850+98.6} - 1\right) \quad (16)$$

$$Rv = 1.32 \text{ m}^3\text{/month} \quad (17)$$

$$\text{or } Rv = 44.0 \text{ Liters/connection/day} \quad (18)$$

Calculation of monthly amount recovered value, considering the second tariff band using T2 = $2.47 and the sewage collection, transportation and treatment service, the monthly amount recovered is multiplied by 2, substituting in the Eq. (16):

$$Rv = 16\left(\frac{-0.0013\ .\ 0+98.6}{-0.0013\ .\ 850+98.6} - 1\right) .2.47\ .\ 2 \quad (19)$$

$$Rv = \$\ 6.52\text{/month} \quad (20)$$

In this case replacing an old unijet velocity meter (x) by a new volumetric meter (y), will provide a recovered billing amount of $ 6.52/month.

8. Feasibility Assessment of the Volumetric Meter

Cash Flow replacing the old meter by a volumetric meter (y) of a 1.5 m³/h class C with Cost = 2C ($ 50.80), will have a NPV = $24.12 and the payback in 8 months, making it the most advantageous replacing option.

Is possible to conclude that although the cost of the volumetric meter is higher, the financial result after 1 (one) year is favorable to the application of volumetric technology to clients with profile of the example presented.

9. Scenario Evaluation

Based on this study it will be possible to evaluate scenarios for each case, as the next example:

Example 3: To customers with accumulated consumption around 1,000 m³ in total riding (Fig. 5), with installed velocity meters and establishing the financial return for each type of meter, it is possible to create a scenario for decision making in which technology to be employed. In this analysis a rate of 12% per year was adopted.

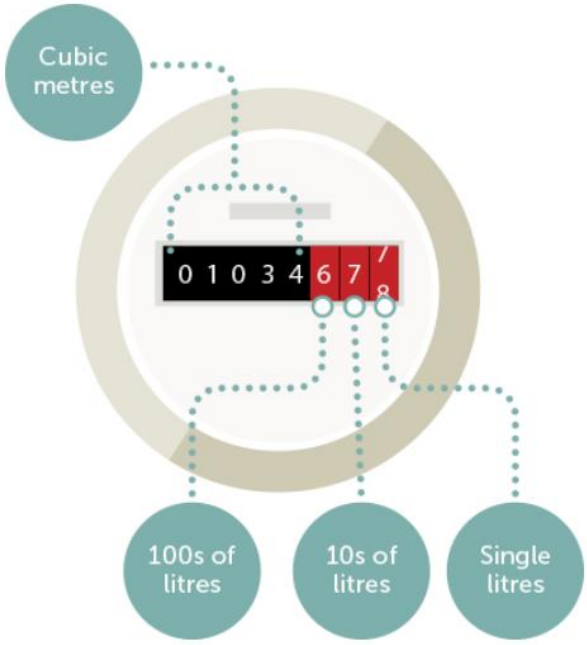

Fig. 5 Water meter readings 1,000 m³ in average [3].

10. Decision Making Based in Presented Scenario

For meters with a total reading around 1,000 m³ found in water system, the technology to be used for each replacement will be defined based on the Internal Rate of Return (IRR), that should be close or above the established interest rate, adopting as the best option the largest net present value presented by comparing technologies. Based on this premise reaching the following conclusions:

- Velocity meters, 0 to 15 m³/month;

In application of velocity meters to consumption between 0 to 15 m³/month, in the case of the adopted tariff structure, where the minimum tariff is 15 m³/month, there will be no significant financial return on replacing, but its replacement or subsequent verification at an interval of no more than 7 years is recommended in accordance with Inmetro standards [2], approved by Portaria 295/2018, and for this reason the velocity meter is the best option.

- Volumetric meters, 16 to 30 m³/month;

In application of volumetric meters to consumption between 16 to 30 m³/month, based on Table 3, the volumetric meter is the best option in the consumption

range, between 16 and 30 m³/month considering that the IRR is higher than the ultrasonic meter in this range and the NPV is higher compared to the other technologies.

Table 3 Feasibility analysis by meter types.

Auxiliary plan for replace unijet velocity meters whit 1,000 m³ totalized for other types of technologies									
Average Measured Volume (m³/month)	Unijet Velocity Meter Investment Cost = $ 25.40			Volumetric Meter Investment Cost = $ 50.80			Ultrassonic Meter Investment Cost = $ 152.40		
	Payback	NPV ($) 36 month	Internal Rate of Return	Payback	NPV ($) 36 month	Internal Rate of Return	PAYBACK	NPV ($) 36 month	Internal Rate of Return
14	13	27,42	8%	11	85,10	9%	27	16,13	2%
15	11	35,39	10%	10	100,00	11%	24	34,31	3%
16	10	43,96	11%	10	115,62	12%	22	53,34	3%
17	9	53,11	13%	9	131,96	13%	20	73,24	4%
18	8	62,86	15%	8	149,05	15%	19	94,00	5%
19	7	73,21	17%	8	166,87	16%	17	115,65	5%
20	7	84,16	19%	7	185,43	17%	16	138,17	6%
21	6	95,72	21%	7	204,75	19%	15	161,59	7%
22	6	107,90	24%	6	224,83	21%	14	185,90	7%
23	5	120,69	26%	6	245,67	22%	13	211,12	8%
24	5	134,11	29%	6	267,28	24%	12	237,25	9%
25	5	148,17	32%	5	289,67	26%	12	264,31	9%
26	4	162,85	34%	5	312,85	27%	11	292,29	10%
27	4	178,18	37%	5	336,81	29%	11	321,20	11%
28	4	194,15	40%	5	361,57	31%	10	351,06	12%
29	4	210,78	44%	4	387,14	33%	10	381,88	12%
30	4	228,06	47%	4	413,51	35%	9	413,65	13%
31	3	270,36	55%	4	484,82	41%	8	500,12	15%
32	3	290,64	59%	4	515,35	43%	8	536,87	16%
33	3	311,66	63%	4	546,79	46%	7	574,68	17%
34	3	333,42	67%	4	579,14	48%	7	613,58	18%
35	3	355,92	72%	3	612,42	51%	7	653,57	19%

- Static meters, over than 30 m³/month.

In application of static meters to consumption over than 30 m³/month, it is observed that the ultrasonic technology is shown as a preferred option, because the NPV is higher. The IRR is also above 12% proving the viability of the strategy employed.

11. Conclusions

Based on the study, it was concluded that the presented method can be used in different tariff structures and will allow the correct choice of which technology to use.

The results presented demonstrated that meter replaces are necessary and actions must be performed with defined criteria and methods aiming at the highest possible return of investment.

Due to the diversification of installed meters in water system the proposed method is effective as long as it is defining for each niche of customers to the distinct technologies. Giving the best results with the lowest investment.

Static meters, despite their high cost, prove to be viable as long as it is preceded of the presented statements.

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Restoration and Promotion of Sports Facilities: A Project of Urban Renewal

Stefano Bertocci[1], Silvia La Placa[2], and Marco Ricciarini[1]

1. Department of Architecture, University of Florence, Italy

2. Department of Civil Engineering and Architecture, University of Pavia, Italy

Abstract: Sports facilities represent a crucial node in the development of social connections, in opposition to the alienation and isolation that nowadays are constantly encouraged by the use of technology. Sport activities seem to be the last resort to face a series of lazy and indolent behaviors that increasingly belong to sedentary young people. The planning phase, aimed at the restoration and promotion of those infrastructures, becomes significant in order to stimulate not only physical activities in teams but also socialization on a larger scale. For this reason, the Architecture Department of University of Florence has started a project with ANCI Toscana for researching and validating hot spots all around the city first, and creating new ones later on.

Key words: urban renewal, sports facilities, restoration

1. Sociality in the Contemporary City

> "We are an extraordinary and beautiful country, but at the same time very fragile. The landscape is fragile and cities are fragile, especially the suburbs where no one has spent time and money on maintenance. But it is precisely the peripheries that are the city of the future, the one where human energy is concentrated and the one that we will bequeath to our children. [...]"
>
> (Renzo Piano, 2014)

The term city, from the Greek *polis* to the industrial revolution, could be considered synonymous with continuity and homogeneous growth. The enormous transformation that has taken place since the early nineteenth century has fundamentally reversed this concept: we are no longer able to imagine an expanding nucleus because we have lost the idea of border. The contemporary city is shapeless, representable only as a set of territories linked to each other by displacement systems now more technological than physical. The speed of the processes of change, which have been going on in recent decades, is such that they cannot be absorbed by the pre-existing historical and social conditions. As a result, we find ourselves encased in undefined spaces, of which it is possible to identify only the original nuclei and whose stratification and expansion are gradually less readable and continuous. Therefore, it seems necessary to investigate new and different methodologies for the analysis and understanding of the present city, in order to indicate the critical and crucial nodes for the territory and its social relations. The walls, which defined the towns while connoting them from a physical and cultural point of view, have renounced in favour of a very different perimeter, an urban landscape with an indefinite shape, within which, however, a precise architectural approach finds expression — from place to place. While, in the past, cities grew along an expansive logic of necessity, connecting private spaces to the public ones, today the urban frame reveals voids and seams in marginal areas. But can we truly speak of margins, given the aforementioned loss of boundaries

Corresponding author: Marco Ricciarini, Ph.D.; research areas/interests: architecture, 3D survey, databases, cultural heritage, urban systems, sports architecture. E-mail: marco.ricciarini@unifi.it.

and definitions? More than spatial margins, we should talk about social conditions, with their own identity and with certain economic, cultural and development perspectives. These areas appear isolated not only from a local point of view (we speak of suburbs: from the Greek *periphéreia* "circumference", derivative of *periphér'*s "port around, turn"[1] [1]), but above all from that of architectural commitment. They seem to be born randomly, in absence of design and, therefore, of connection between the parties. Their seemingly weak and now compromised state makes them perfect scenes for the study and development of quality contemporary architecture. Since the fabric on which they insist appears free from the archaeological and spatial limits imposed elsewhere, the periphery represents the ideal place to experience architecture. Here we have an openness to change, which is lacking for obvious historical reasons, in the ancient housing units. The suburbs are, therefore, the future of cities, because of the number of their inhabitants and their inherent potential: the great urban voids that make them islands today, could tomorrow be bridges, constituted by public, relational and social structures. We need an architecture of redevelopment and sharing, which could enrich with functions and cultural baggage the well-known areas of urban degradation.

2. Design Enhancement

If the industrial revolution has upended the organization and shape of our cities, with the technological revolution we were all led to believe that we have no limits and boundaries. Computers, smartphones and tablets have substantially increased the speed and quantity of daily actions, allowing us to create an additional and more extensive work and relational network. The imposition of computer technology in communication, however, can also lead to the alienation of the individual from the group: this is particularly the case of the last generations, who are most involved. Architecture, in this sense, can become a decisive and fruitful tool for peripheral areas that lack connective and collective urban fabrics. A hypothesis of an all-round redevelopment of degraded areas may be exemplified by the design of architectures for sport. In fact, sports activities seem to be able, in their wider beneficial sense, to help with a series of deviant behaviours that are often found in sedentary young people. If in a general comparison the term sport is usually employed to identify only competitive or professional contests, this is not the case for the "European Charter of Sport" of 1992, which defines it as: "(...) any form of physical activity which, through organized participation or not, is aimed at the expression or improvement of physical and mental condition, the development of social relationships or the obtaining of results in competitions of all levels." Sports practice is, therefore, to be understood as a right for a healthy lifestyle and a balanced psycho-physical development. This is a significant moment especially for young people who, through sports, learn civil confrontation and begin to establish the first interpersonal relationships, understanding the principles of commitment, respect and fair play. The European Commission (February 2013) has set out a number of goals, including the removal of economic, physical and cultural obstacles, in order to ensure that all children can participate in recreational, sporting and recreational activities, also outside of school. The planning for the recovery and enhancement of sports facilities is therefore of considerable importance, as it becomes essential for the development of wide-ranging socialization processes, i.e., not exclusively limited to sports activities.[2] The architects in charge of the structures have the task of conceiving spaces of social life, in which the sporting, ethical and civil identity of the athletes will be promoted in the future. Sport also

[1] The definition is taken up by the dictionary of ancient Greek.

[2] "The Italian Government has established the Sport and Suburbs Fund, which allows construction work for sports equipment to be carried out. In particular, the fund is used for recovery and redevelopment projects of existing plants. Among its aims, in a social way, is the development of the culture of sport at a competitive level. I think it is at http://www.sporteperiferie.it/.

gathers its educational and cultural value from the buildings and environments that host it. Therefore, it is necessary to give these spaces the right design attention and an appropriate social investment, in order to encourage relational and growth exchanges. An opening of this kind can be found in the works of the engineer Nervi[3] [2] who has distinguished itself in the field of sports architecture for his innovative ability, aesthetic taste and social sensitivity. It is worth reflecting, in particular, on its extraordinary contribution to the structural challenges posed by sports facilities from the first stadium built in Florence in 1929 to the Kuwait Sports Centre in 1968 (Fig. 1).

The scientific, technical and systematic research of Nervi begins with the project of the Florentine stadium Giovanni Berta (1929-1932) and develops finding its apex in the three ribbed domes of the Palazzetto dello Sport in Rome (1956-1959), the Palazzo dello Sport at EUR (1955-1959) and the Cultural and Convention Center in Norfolk, Virginia USA (1965-1971)[4] [3]. Despite the conceptual and physical grandeur of Nervi's works, there is the possibility of failing to protect them and therefore not being able to pass them on. This is because sports architectures are excluded from historicalization processes and are often unknown. Understanding their cultural value and scientific innovation is the first step for their diffusion and protection. Nervi was preceded and joined by another great Florentine personality, the Marquis Luigi Ridolfi (1896-1958)[5] [4]. Although little discussed today, the importance of the role of architecture in sports venues had not escaped Ridolfi, who was the promoter of veritable avant-garde initiatives, allowing the city to develop a remarkable implementation from the point of view of sports equipment. He is credited with the construction of the Berta Stadium and the Federal Technical Centre in Coverciano.[6] The latter was born precisely to manifest the link between the sporting and cultural dimensions, and it employs architecture as a tool to achieve the goal. Its distribution, expertly developed by architects Tiezzi and Degli Innocenti[7] [5], was conceived so that the different users could find there adequate spaces to create sharing and connection networks. The center, in addition to its important technological innovations,[8] embeds some areas specifically dedicated to the education of athletes and trainers. The architecture, well integrated in the surrounding context by appropriate material choices, is conceived on a human

Fig. 1 Model for the Kuwait Sports Centre, 1968, Nervi.

[3] Pier Luigi Nervi (1891-1979) engineer, entrepreneur and academic specializing in civil construction.

[4] Among the many facilities designed by Nervi, three in particular have close structural similarities between them: the Eur Sports Palace, the Norfolk Scope Arena (Virginia-USA) and the Palazzetto dello Sport in Rome.

[5] Luigi Ridolfi Vay da Verrazzano (1896-1958) was an esteemed politician and entrepreneur. In the 1920s he pioneered sports at all levels, from Tuscan to national and international.

[6] The Department of Architecture of the University of Florence conducted analyses and surveys at the Federal Technical Center of Coverciano, collected in the thesis work "The Federal Technical Center of Coverciano an architecture for sports education" produced in the 2018, on the occasion of the sixty years since the founding of the Centre, by La Placa S. and Martini B., rapporteur Prof. S. Bertocci S. and arch correspondent M. Ricciarini.

[7] The architects Tiezzi and the Innocenti were students of the best-known Michelucci: their works are characterized by sharp and clean lines and a strict functionalism.

[8] Luigi Ridolfi donated the Technical Center of the most avant-garde technologies of the time: official drawings (available at the State Archives of Florence) and oral testimonies (thank you Dr. Fino Fini, former doctor of the national team and current Director of the museum Coverciano Football) explain the attention to detail for the instruments present in the Magna Hall and in the Center's Medical Center.

Fig. 2 Nuvola di punti del Centro Tecnico Federale di Coverciano, 1958, Tiezzi e Degl'Innocenti.

scale and it is studied in detail in order to fit the perspectives and arrangements of its different functions.

In the light of excellencies from which to benefit and get inputs, such as those mentioned above, sport architectures seem to make themselves more than ever a quality tool for a point-based redevelopment of our suburbs. Therefore, it would be desirable to define a program of interventions aimed at rebalancing the most recurring shortcomings and promoting the development of sports activity in areas of greatest socio-cultural degradation.

3. Sports Equipment Development Projects

In Tuscany, but also at the national level, there are numerous requests for the improvement of sports facilities, [9] which is why the Department of Architecture of the University of Florence has been promoting and supporting, for some years now, research projects related to sports. In the belief that the architectural discipline is capable of contributing to the study, analysis and overcoming the current difficulties of this sector, the Department of Architecture has encouraged the experimentation of a particular and innovative procedure, with the primary objective of generating social change, as well as improving the facility and its equipment. This is how the research project "Kick Away Spaces of Tomorrow" was born, project which saw the Department working in synergy with Italian cycling federation of Tuscany and Italian football federation of Tuscany. In order to obtain a suitable level of quality of amateur centres, first it was considered necessary to activate a path of awareness aimed at workers in the world of sport, in order to be able to know and deal with critical issues in a systematic way. The work has therefore dealt, in a systematic way, with the following issues:

- First, the multiple cultural, historical, economic and architectural dynamics related to sport were evaluated, in order to delineate clearly and briefly the technical evolution of sports equipment. This procedure was necessary to understand the importance these places have nowadays;
- On the basis of spatial and management characteristics, the division of sports facilities into two broad categories was established: those related to amateur associations or societies, and those structured for professional athletes;
- Twenty regional amateur sports facilities [10] were then identified and analysed, working with data management programmes (Filemakers) to obtain and file information on geographical framing, orientation, safety, savings energy, sustainability, functions carried out, auxiliary services, structural types, materials used, state of the art and use of each complex;
- In addition, the integrated survey methodology was then used by laser scanner and photographic tools.
- Through the use of post-production programs (Cyclone, AutoCAD) and from the clouds of laser points it was possible to return a series of two-dimensional and three-dimensional works;

[9] See the FIGC's "Football Report 2,000 Seventeen" and the "First Report on Sport in Tuscany" of the Regional Social Observatory in 2018.

[10] The twenty sports facilities analyzed are collected in the research work of architect Ricciarini M. entitled "The design for sport. Analysis strategies for the development of projects to support sports equipment" in 2018.

Similarly, data from photogrammetry (3Dflow, Photoscan) were developed.

The documentation collected was not only used to assess the actual state-of-the-art of these facilities, but also as a preparatory basis for a series of redevelopment projects undertaken by some of the sports clubs involved. The process that has been triggered underlines the social dimension of "Kick Away Spaces of Tomorrow" and the idea that places of growth must make an important contribution to the definition of quality.

Today, more than ever, it is necessary to qualify the new and diverse function of sports centers spread throughout the territory, ensuring that the facilities do not perform only mere service function but are reconsidered for their social value. Architecture is a plausible and effective tool to achieve this goal, making new interactions possible. It should also be considered that a sports facility is a very impressive reality, which lives not only at the architectural level, but also extends its purpose to an urban scale. It is in this order of magnitude that it is thus necessary to evaluate a possible design, but above all, a suitable redevelopment which puts the economic, constructive, functional and social aspects at the forefront. Studies and analyses carried out in the early stages of the project revealed the great weight of relations and symbiosis with the environment in assessing the quality of a sports facility. If exchanges and positive feelings are generated within it, these contribute significantly to the enrichment and improvement of the individual; if negative, they hamper its growth. This gives us the merits of a complete relief, which allows us to know a place physically but also to analyze it on a psychological level (behavioral relief, architectural psychology). Working with the importance of the latter means working with attention to the environment and in parallel with the mental and relational attitudes among the individuals who attend it, with the aim of creating and presenting the best conditions for a person-environment relationship balance. In sports,

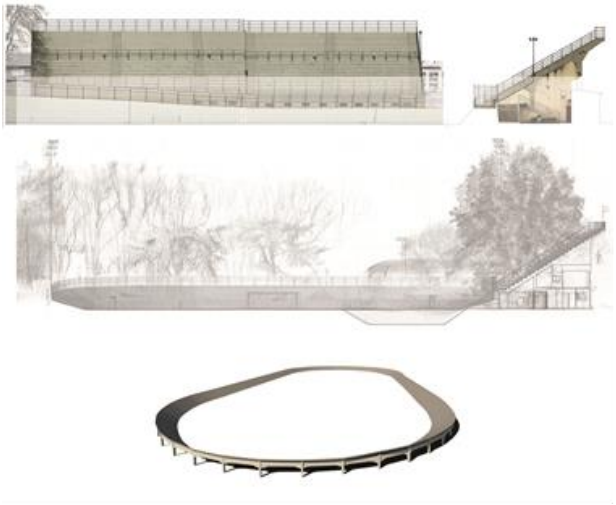

Fig. 3 Velodrome of the Cascine in Florence, during the sportsmanship phase of the city of Florence in the late 1800s was one of the symbolic places.

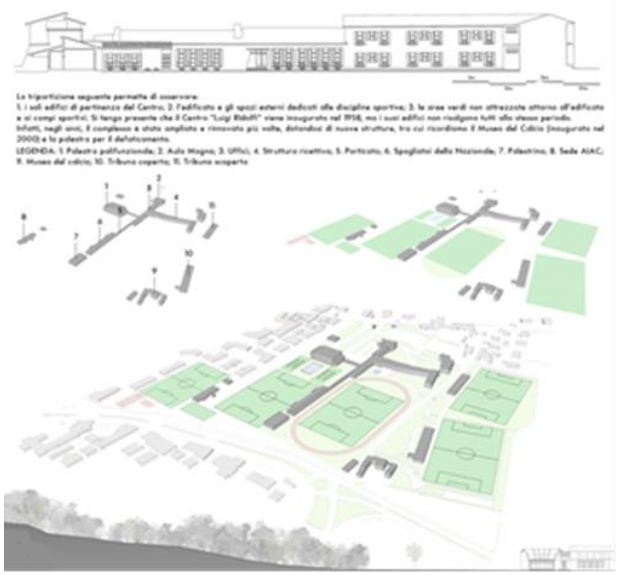

Fig. 4 Federal Technical Center of Coverciano, 1958. Analysis of the volumes and activity spaces of the sports facility.

this would result in the construction of a place capable of positively influencing both the performance of the professional athlete and the psychophysical development of the growing young person. This situation can be found in the sports center of excellence of Coverciano, first mentioned, and also analyzed by the Department. Again, the operational methodologies followed have seen the use of diversified tools both in the study and understanding of spaces (Filemaker),

both in the field of analysis (laser scanners and photographic equipment) and in the process of (Cyclone, 3Dflow, AutoCAD). The aim of the research was to demonstrate the importance of the connection between architecture and places of sport and therefore of social interactions. The diffusion of the result achieved may be a starting point for amateur centres that wish to pursue high quality levels.

To date, the Regional Social Observatory Sport of the Tuscany Region, ANCI Tuscany and the Department of Architecture of the University of Florence are jointly engaged in the activation of an additional research project. The architectural heritage of sports facilities, from large stadiums, to arenas to small swimming pools and suburban campsites, is owned by the public administrations. These, through specific agreements, give the management of the plants to different companies operating in the territory.

The split between the administrator and the manager of the asset has in fact led, over time, to a decreasing architectural and environmental quality of these places. It is intended to enable the resolutive proposals suggested to address the inadequacy that is often found at the functional and architectural level in sports facilities. All this in light of the enormous imbalance to be fixed between the quality of the facilities and the massive use that children, teens and even adults make of them.

Sports facilities are a key place for the community; however, at the expense of their social value, they find themselves forced into an absolutely inadequate architectural heritage that deserves more attention both structurally and from a urban point of view.

Therefore, in view of the need for systematic and urgent interventions, this experimental and innovative project in support of public administrations was born, in the belief that their safety and modernization is a priority for the social purposes of the Tuscany Region.

Another aim of this project is to promote modern design lines for sports facilities, characterised by innovation in the fields of energy saving, safety and removal of architectural barriers.

The project will involve all interested amateur centres present in Tuscany, but priority will be given to those with obvious major deficiencies.

When completed, the local administrations will be able to take advantage of an analysis — carried out by the Department of Architecture — on the de facto status of the structures that they consider strategic and functional for the territory, so that they can be supported in the verification. Local administration will thus be able to jointly activate an evaluation path for the adaptation and redevelopment of the same centres. This will be all the more valid for those sports facilities of historical importance; the analysis and development of these centres will allow to create a “pilot” program suitable for the regeneration of other spaces.

4. Conclusion

The objective of peripheral regeneration, in social, urban and architectural terms, is a necessity: it is necessary to update the housing model if we want to respond to new corporate needs. The projects activated by the Florence Department of Architecture for the redevelopment of sports facilities make a contribution and allow a reflection on the plausible methodologies of intervention. Starting from an accurate analysis of the problems and needs it is possible to restore full dignity to the city’s tissues as well as modernize the country. We need to focus on social gathering spaces in order to restore lifeblood to brownfield areas and to relaunch services; It is also appropriate to design with the right focus on aspects of sustainability and energy efficiency.

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Contemporary Architectural Design in Urban Historic Sites — Future Heritages

Chien Thang Le

Institute of Training and International Cooperation, Hanoi Architectural University, Vietnam

Abstract: Design in the historic urban sites has been noticed since the 1980s with efforts to preserve the architectural heritage and urban space. The design in this area is a real challenge for architects in balancing of cultural, architectural and sustainable development features with functional, aesthetic and spatial changes. This paper focuses on the ideas and design solutions of leading contemporary architects in different historical contexts to make lessons learned for developing countries, including Vietnam, to create the future heritage which is protected by regulation, communities.

Key words: historic urban site, contemporary design, local identity, globalization

1. Introduction

In the 1980s, heritage conservation had emerged important issues with many reconstruction and redevelopment projects, especially in Europe. Its importance was associated with the loss of the European cultural heritages in general and urban architecture heritage in particular in the wartime as well as post-war period of World War II. It was worth mentioning that the huge loss also took place in the post-war period, when many major reconstruction projects even put the loss of historic structures more quickly. These losses caused the remaining historic areas or structures to be protected quickly and extensively with multi-level and international protection measures. Conservative concepts as well as approaches have been expanded and adapted to many different circumstances, towards the sustainable development of heritage, focus on the balance between conservation and sustainable development. Conservation subjects have also been expanded from single buildings to historic urban landscape spaces around the buildings. The acceptance of new buildings intermingling within the historical buildings or areas also aimed to bring contemporary vitality to that buildings or areas. Some important concepts were defined in the conservation and development of the values of a building or an entire area:

Zeitgeist: “spirit of the age” or “spirit of the times”. It refers to an invisible agent or force dominating the characteristics of a given epoch in world history [1]. Contemporary use of the term may, more pragmatically, refer to a schema of fashions or fads that prescribes what is considered to be acceptable or tasteful for an era, e.g., in the field of architecture [2].

Sense of place: buildings or areas are always closely linked to a location/place. The location itself gives the building or the landscape and the region the unique difference. Locations may become more important after time. In order to assess the location, it is necessary to analyze the stable components over a long period, the stable components includes and high stable components and low stable components that often change or change in a short time. Such components help buildings or areas tell us about the past, present and future.

Corresponding author: Chien Thang Le, Doctor; research area/interest: sustainable architecture, architectural history and conservation. E-mail: thang.lc@hau.edu.vn.

2. Heritage and New Buildings

Cultural heritage (tangible and intangible) has been an important part of the human living environment. Human are both cultural creators and owners of cultural assets, so cultural heritage must always be associated with human and meet the cultural needs of the community. However, human has been also the main agent that has transformed heritages which cannot be renewed. Modern conservative methods have also allowed forms of renovation and redevelopment, especially urban architectural heritage, to preserve and bring heritage to sustainable development through continued participation into the activities of contemporary life. In addition to preserving each individual project, UNESCO also introduced the concept of conservation of larger spaces: historical urban landscape (HUL). The conference on "*World Heritage and Contemporary Architecture — Historical Urban Landscape Management*" in Vienna (Austria) established declaration on the preservation of historic urban landscape in the Vienna Memorandum [3]. Preserving and promoting the urban landscape environmental values is composed of architectural heritage quantity, construction techniques, architectural design, building technology and conservation. This is a complex process with many contents such as defining the structural characteristics and specific urban spatial patterns and development trends for each region; classification of conservation structures and forms; architectural heritage fund; boundaries of heritage protection areas; oriented development and future functions of each region and the overall link; height, morphology, sites and landmarks on respect of historical urban structures. Many UNESCO guidelines have provided stakeholders with a way to integrate policies and practices of environmental conservation into a wider international goal of urban development while respecting different cultural values of the context.

Contemporary cities have been participating directly or indirectly in different scales in the globalization process. Globalization helps bring peoples, economies or nations closer together. Globalization stimulates the exchange of information, finance or people. However, globalization has also created consequences, the most important and most obvious of which is the loss of specific local cultural identities, including architecture. Modern globalization began to be popular since the 1950s, coinciding with the time when the international-style of modern architecture began to be criticized for its lack of identity or lack cultural soul. Many architectural subsequent experiments have shown that the cultural flows or sense of places always plays a very important role in architecture. There were some emerging trends, movements or styles such as Historicism, Post-Modernism as well as Regionalism. However, the legacy of modernism shows that there were many variations as well as new tests based on it (New Modernism, Local Modernism...) that showed the variety in this post-modern era. Such parallel styles/movements/trends reflects the social development at this time: global-local, historical-contemporary.

In historical urban areas, such parallel development also takes place, arguments have shown that there are two different streams of thought. On one side, with the point of view of the status quo preserving and all new buildings must be in line with the historical elements of styles, colors, building materials, decoration... to show the discretion and partly safer, easier to predict the result of that construction because the boundary between old and new is not entirely clear. This view is easily accepted from stakeholders such as policy makers, managers, community owners and users.... This view is also particularly suitable for areas with low and medium levels of development where technological or material breakthroughs are not common in society. The other side with a point of view that derives from the benefits of the contemporary generation in creating the imprints of the times, the change in the ability to adapt to the ever-changing and rapidly changing. The buildings that follow this point

of view are likely to cause intense debates, its results are not so predictable and sometimes it takes time to verify. Moreover, a mistake in design or problem of new buildings can also create disadvantages if the project is listed in the UNESCO world cultural heritage, which creates pressures for managers. However, with leading cities in global networks such as Tokyo, London, Paris, New York ... or emerging economic cities are eager to make their mark and redundancy, creating breakthroughs in design will bring the echo, attention and create a thrust for economic development for the city as well as the country as effectively as the works such as the Guggenheim Museum Bilbao, Centre Georges Pompidou for Spain and France respectively.

For architects, their work will probably be easier when there are many legal barriers and constraints, their role may be enhanced due to design difficulties in the historical site. Strict management in the historical site is necessary to preserve for the next generations but developing is the responsibility of the contemporary and future generations. Cities in general and urban architectural heritage in particular will always change according to the transformation of the age, but how change is important in accordance with the development orientation, existing resources, community knowledge as well as talent of designers. The following examples may also give us lessons on this issue.

3. Typical Projects

The following typical buildings come from different countries. They were built in the same period that the important transformation of society as well as the heritage community showed the importance of these works. And at present, it has been sufficient to verify their success:

- Haas Haus, Architect Hans Hollein, Vienna, Austria, 1985-1990.
- Contemporary art center (Carré d'Art), Arch. Norman Foster, Nimes, France, 1984-1993.
- Barcelona Museum of Contemporary Art, Architect Richard Meier, Barcelona, Spain, 1987-1995.
- Pyramid of Louvre Museum, Architect I. M. Pei, Paris, France, 1989.

The common point of the above buildings is located in the cities with high level of development in Europe, designed by world-class architects. The style chosen is Neo-modernism. However, at the time of design and construction, these projects encountered many difficulties due to the intense debate over the media as well as in the design sphere. There have even been widespread confrontations in the public opinion of both the city and the nation due to the importance of the historical site and the heritage surrounding the new buildings. The Haas Haus is located in Vienna’s historic center, opposite St.Stephan Cathedral (1160); the Carré d'Art is opposite Maison Carrée (built in the 2nd century AD); the Barcelona Museum of Contemporary Art is located in the typical Gothic Quarter of the city; the Pyramid of I. M. Pei is located in the middle of the Louvre Museum’s Napoleon courtyard. These historical contexts show that architects' importance and suggestions need the highest discretion, although at this time, they were all famous architects with the Pritzker prestigious award: IMPei (1983), Richard Meier (1984) or Hans Hollein (1985). However, they have all succeeded with their proposals with decades of verification. The buildings have unique design solutions, very specific for the location (landscape, construction, space...).

3.1 Haas Haus, Hans Hollein, Vienna, Austria, 1985-1990

The multi-use complex of glass and stone is considered an extension of St. Stephen’s church when architects use large curved glass in reflecting/ duplicating the church’s silhoutte as well as the classic works around on it. The stone wall adjacent to old building is designed to resemble the horizontal units. The whole building is like being lifted up with pillars

according to the overlapping of construction works in the old period. The highlight of the building is the entrance with the skewed blocks supporting the protruding glass cylinder. The entire work shows that modern architecture can also stand out without disrupting the surrounding historical context.

Fig. 1 Haas Haus (left) and Carré d'Art (right).

3.2 Carré d'Art, Norman Foster, Nimes, France, 1984-1993

This center of visual arts and multimedia communication is a cultural institution of contemporary life, complementing the missing functions in this urban space. However, the location of the building has become a great challenge for Foster and colleagues for designing a new building that reflects its contemporarity but still maintain the integrity in the historical site with opposite Maison Carrée — the Roman temple built in the 2nd AD and is one of the best preserved Roman architecture — a heritage of world culture. However, architects do not rely on classical elements but use modern shapes, materials and technology to create a new work. The nine-storey building, half submerged in the ground, creates a moderate height that blends into the historical context. The interior with large floor spaces combined with glass roofs, steel columns and large louver panels not only brings visual effects and social interaction inside the building, but also opens dialogues between ancient-new blocks, between the internal-external space, between the old and modern materials.

3.3 Museum of Contemporary Art of Barcelona, Richard Meier, 1987-1995

Richard Meier created a work which is called “the pearl” by the local media among ancient architecture just a few blocks from Gothic Quarter of Barcelona. Meier's modern, white and grandiose building, extends the southern façade with large glass façade, opening to the Plaça dels Angels to create good view and natural lighting for the galleries. The contrast of shapes, materials, colors ... as well as the smoothness of the building and the surrounding landscape and architecture has created a gentle dialogue between the old and the new as well as surprising visitors in the ancient space area of Barcelona city.

3.4 Pyramid of Louvre museum, Paris, France, I. M. Pei, 1989

This can be the most turbulent project related to the special location and the values as well as the great significance of the museum with Paris in particular and with France as well as the world in general. The long controversies, the objections of the parties to the project have made the success of I. M. Pei’s design solution. The underground entrance to exhibition wings reduces the maximum intervention into the historical landscape. In addition, the simple and long-lasting pyramid shape creates contrast special here. However, pyramid shapes are not simply placed here but are carefully calculated to harmonize between the old and the new which are hidden in the shape and material of the building. Once again, the special glass

works, which reflects the surrounding old building wings very successfully on the surface but does not reduce the transparency of the inner space, are the most important element for the success of the project. As Haas Haus, glass is the dominant material with the properties of reflecting/duplicating surrounding objects. The special glass here reflects the work very successfully on the surface but does not reduce the transparency of the inner space. The inclination of the pyramid edges is perfectly proportional to the shape of the museum wings. Ten years after its completion, the museum pyramid became the new symbol of Paris, successfully convincing the most fastidious people.

Fig. 2 Museum of contemporary Barcelona.

Fig. 3 Pyramid of Louvre (left) & Hilton Opera Hotel, Hanoi, Vietnam, E. Chambure & P. Pascal, 1999 (right).

4. Future Heritage

The above works are successful with different contexts and tactics, however learning from them requires local analysis. With cultural heritage, Vietnam also has losses due to historical circumstance and this could be irreparable. The story of Vietnam is like many other countries, the heritage is lost during the war as similar as in the period of reconstruction and economic development after that. Besides, Vietnam is in the development stage. Globalization has also spread to Vietnam, the pressure on cultural diversity and cultural characteristics also requires Vietnam to take drastic actions. Recent noisy stories in Ho Chi Minh City, Da Lat or Nam Dinh city about how to deal with heritage

have opened up international debates. Vietnam is lacking a lot of important foundations to preserve heritage or decide how to behave with heritage. The question is whether Hanoi or major cities of Vietnam dare to break through and participate deeply in the global city network in the future? If yes, how is the level determined? Only accurate planning is expected to have such breakthroughs.

Change is inevitable as is the process of globalization. But how to change? Buildings, landscapes, streets and urban areas are always evolving and changing according to people's needs. So what role does architecture play in that change towards preserving and honoring the historical environment that the community has recognized and desires to preserve for future generations. The most important issue in the construction of new buildings in historic urban areas is not the architectural style but the relationship between the old and new buildings. Issues such as location, scale, architectural style, construction materials, colors and details are important when assessing the impact of new buildings or projects in historical urban areas. Most of the new projects that were successful as analyzed above are based on a deep understanding of the location, space as well as social issues in both history and contemporary from which to propose contemporary solutions responding to special characteristics and qualities of that context.

Cities with a unified historical site of architectural forms, structures or construction materials may need a different approach to centers have various forms of architecture, scale or construction materials. Homogeneous cities such as Toulouse (France) or Marraketch (Marocco), which are known as cities of "brick" or "red" cities, can continue to maintain construction techniques or manual materials in new projects. As for areas that are developing diversely or need big breakthroughs to create advertising images and tourist attraction can choose solutions with special projects (landmark).

In Vietnam, Hanoi's historic urban areas tend to choose safer solutions with organic cohesion in style, color or material. These types of construction solutions are likely to be more acceptable when approaching inward from inside out, which goes into issues of supplementing functions, spatial stories or local culture rather than a new global technology or materials. Some buildings have also been successful such as the Hilton Opera Hotel next to the Opera House or many other buildings with a classic shape but modern materials, structures and spaces.

The starting point for new design projects in historic urban areas should begin with the assessment of the existing value of the context as well as the construction site. These values should be interpreted as subjects that need to be protected by law and the community in both present and future to continue to maintain meaning and enhance that value. The responsibility of architects is to ensure that their design results will contribute to enriching the construction environment here. Conservation regulations can be viewed as binding but can also be viewed as an opportunity for creativity. New buildings in the historical site need to be considered with the existing relationships and future relationships between the existing and new works after completion. This whole has a greater value than the sum of the components, and the new building must add new features, new functions on the basis of respecting the existing features of the region. New buildings need to create a legacy of the future and are worth being protected by future generations.

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Mining Pollution and Infant Health in Modern Japan: From Village/Town Statistics of Infant Mortality

Keisuke Moriya, and Kenichi Tomobe
Graduate School of Economics, Hitotsubashi University, Japan

Abstract: The purpose of the paper is to explain the relationship between infant mortality rate (IMR) and mining pollution. In Japan, the pollution became a problem in various places in the 1960's, but it had occurred since then. For example, around Ashio Copper Mine in Tochigi Prefecture, the mining pollution had been occurring since 1880's, and it had become a social problem in Japan. In our previous analysis, the IMR in Japan have declined irreversibly since 1920's because people got over the beriberi and syphilis, but in the specific area, such as mining area, the IMR remained still high rate in 1930's. So we will consider the relationship between the IMR and mining pollution.

Key words: infant mortality, mining pollution, environmental pollution

1. Environmental Pollution and Infant Mortality

In the historical studies, the focus of the relationship between environmental pollution and infant mortality has been air pollution. Many researches have focused on analyzing the effects of air pollution, including research by Bailey, Timothy J., Kris Inwood (2018) [1]. Their research on the effects of coal use in Britain has identified negative effects on the infant mortality, and the health of children in the late 19th century. There are also many studies on air pollution and the health of children in developing countries. Air pollution has been regarded as a problem since the Industrial Revolution. In Japan, air pollution of sulfur oxides and nitrogen oxides caused by industrialization, including the smoke damage of Besshi Copper Mine and Yokkaichi Asthma, has become a social problem. Moreover, the WHO report (2017) [2] also states that air pollution is the biggest cause of infant mortality from environmental pollution.

Corresponding author: Keisuke Moriya, Graduate Student; research area/interest: social science history. E-mail: k3000scw@gmail.com.

Many researches on water pollution have focused on epidemiology, or the inadequacies of water supply and sewage systems in densely populated towns. Cain and Rotella found that sanitary reforms were important in reducing infant mortality in the United States. In the WHO report (2017) [2], infant deaths due to water pollution accounted for a large weight, and the cause was diarrheal disease due to inaccessibility of clean drinking water due to insufficient public health. It is also related to the ongoing threat of waterborne infectious diseases, especially in developing countries, and countermeasures are urgently needed. For this reason, there have been few researches on history of water pollution and soil pollution due to mining pollution.

However, in Japan, very unique statistics on infant mortality have existed. The group called Aiikukai has compiled statistics on births, stillbirths, and infant deaths in 1933 for each town and village all over the Japan and the Ministry of Health and Welfare has compiled the same ones in 1938. Bailey (2018) [1] uses a household date and is characterized by the ability to investigate individual person. There are no such statistics in Japan, but it is possible to analyze the

geographic aspect of the infant mortality rate. In Japan, heavy metal poisoning due to mining pollution has been pointed out for a long time, but there are few historical studies. Therefore, in this study, we would like to analyze the spread of mine pollution using the unique statistics.

As mentioned above, historical researches on environmental pollution and infant mortality, as well as modern research, have focused on air pollution. In particular, historical studies have discussed the relationship between coal-based air pollution and infant mortality. Bailey (2018) [1] using Army Service Records stated that air pollution negatively affects the health of children and post-adult height. Karen et al. (2016) [3] studied the effects of the installation of coal-fired electricity generating plants in the United States between 1930 and 1962, finding that this increased infant mortality within a 30-miles. These studies have shown that air pollution has the negative impact on health of children and later life.

On the other hand, there are few studies on water pollution and air pollution in historical research, and there are some studies focusing on the modern era. According to the study by Michael Greenstone and Rema Hanna (2014) [4], there was no significant difference in water quality control in India, although there was a decline in infant mortality due to air pollution control. The research of Elizabeth Brainerd and Nidhiya Menon (2014) [5] examined that the difference in seasonal planted crops in India changed the concentration of pesticides in water due to the use of pesticides, which negatively affects the health of infants. And it has been found that the poor are most affected. Guojun He and Jeffery M. Perloff (2016) [6] found that invisible contamination of surface water in China increased infant mortality, but when pollution becomes more visible, people take action to avoid polluted water. Therefore, the infant mortality rate will be improved.

Kyi Mar Wai et al. (2017) [7] examined heavy metal poisoning and infant mortality. It was indicated that cadmium exposure was associated with low birth weight (weight less than 2500 g at birth), and low birth weight increased infant mortality. It was also said that there was no relationship with premature birth. But according to Jie Yang et al. (2016) [8], in China, there was a relationship between cadmium concentration and premature birth. Although it may vary depending on the amount of exposure between groups, it is undeniable that heavy metal poisoning cause premature birth, low birth weight, and the resulting increase in infant mortality. In Japan, during late 19th century, there was the mine damage called the Ashio Copper Mine Poisoning Incident. In the mine damage that spread over Gunma Prefecture and Tochigi Prefecture near Tokyo, the flooding of the Watarase River contaminated the soil with heavy metals, withered rice and mulberry, and then was exposed to repeated flooding and heavy metal contamination, resulting in a decline in fertility rates. There were also increases in stillbirth and infant mortality.

Also, from the 1920s to the 1960s, the unusual disease called “Itai-itai disease”, which caused severe pain throughout the body and broke bones, was prevalent in the Jintsu River basin in Toyama Prefecture. In the later studies, the cause was drainage from the upstream mine, which contained a large amount of cadmium, which was accumulated in fish and food, causing heavy metal poisoning inside the human body through meals.

In the light of these results might expect significant effects of heavy metal poisoning. Nevertheless, there are few historical studies on heavy metal poisoning caused by mining pollution. Although soil contamination caused by heavy metal poisoning have been discussed, there are few studies on the effects of it on the human body. Therefore, in this paper, I would like to find the negative effects caused by mining pollution, especially the relationship with infant mortality.

2. Mechanism of Water Pollution and Soil Pollution

The mechanism of water pollution and soil pollution is as follows. When ores are mined, unnecessary ores are discarded. After they are exposed to rainwater, heavy metals are run out, and the water is mixed and contaminated in rivers and soils. In addition, polluted water containing heavy metals and mud generated during the beneficiation, and waste ores and wastewater containing heavy metals generated during metal refining. These wastes pollute rivers and soil. It can also be polluted by floods. Because a large amount of timber is used during refining, flooding is occurred and a large amount of waste ore thrown into ponds and rivers run out. Moreover, SOx and NOx cause the trees around the mine to wither, so the water retention capacity of the mountain is lost and it causes frequent flooding. Once a flood occurs, waste ore that has accumulated in large quantities in the upstream reaches the downstream. Since waste ore contains a lot of heavy metals, the soil and rivers in the downstream area are immediately contaminated with heavy metals. Heavy metals accumulate in fish and crops from contaminated water and soil, and these accumulate in the human body that ate foods, so people are polluted by heavy metal. In particular, when the mother becomes poisoned with heavy metals, the fetus and infants are more affected due to bioconcentration[1], and the IMR and the stillbirth rates increase. Because of this mechanism, the IMR is not necessarily high in the towns and villages near the mine, but it is sometimes very high in the towns and villages in the middle and lower reaches of the river.

3. Characteristics of the Statistics

The data we use for analysis is very unique. It was compiled by the group called Aiikukai, and statistics on birth, stillbirth, and infant death in 1933 were compiled by each prefecture, county, and town, village. Aiikukai was the imperial foundation founded by the Emperor of Japan in 1934. In the early 1930's, public health centers and the Ministry of Welfare were not established in Japan. The government gave the important role of protecting children and mothers health to the Aiikukai to promote health research and development. At that time, Japan had no Ministry of Health and no health care for children and mothers. This was a statistic prepared by the research group and can be analyzed by each town and village. The "Statistics on Birth, Stillbirth and Infant Death by National Prefectural County, Municipalities" created by the Ministry of Health and Welfare, established in 1938, was the same survey conducted in 1938 by the Aiikukai. These two statistics were researched in the same way, so it is possible to analyze the time series by villages and towns.

4. Analysis

In this analysis, the villages and towns around the Yoneshiro River in Akita Prefecture were targeted. Akita Prefecture is located in the northern part of Japan, and the Yoneshiro River basin has many mines upstream, including the Kosaka Mine and Osarizawa Mine (Fig. 1). At the Kosaka River near the Kosaka Mine, it was polluted by the drainage from the mine and fish could no longer be seen. At the Osarizawa Mine, waste and sludge containing heavy metals were washed away by the floods, causing significant damage. It has been the area known to have been damaged by mining pollution. The analysis targets are 65 towns and villages in Kazuno County, Kitaakita County and Yamamoto County aournd the Yoneshiro River. We use the infant mortality rate (IMR) and the stillbirth rate (SBR) in 1938 as the objective variables and the linear distance from Yoneshiro River where the source of mining pollution as the explanatory variable.

The analysis results are shown in Tables 1, 2 and Fig. 2. The distance from the Yoneshiro Riveer and the IMR were found to be negatively related. On the other hand,

[1] Bioconcentration is the phenomenon in which certain chemical substances are concentrated in the organism through the food chain in the ecosystem.

no correlation was obtained for the distance and the SBR.

As a result, it was found that the IMR was higher around the Yoneshiro River due to river pollution because of mining pollution. This can be clear by looking at Fig. 3. This Figure is created using GIS. The IMR is not necessarily high near the mine, but the IMR is high in the middle and lower reaches of the Yoneshiro River. Near the mine, the river does not accumulate so much in the rapid stream in the upstream area, and there is a deposit of mine from the place where the flow becomes slow. In the county's date, IMR was 131.4 for Akita Prefecture as a whole, 145.3 for Kazuno County, 166.9 for Kitaakita County, and 144.7 for Yamamoto County. This result may state that the mining pollution affected infant mortlity in the three counties as a whole. In addition, Akebono Village, Miyagawa Village and Nishikigi Village in Kazuno County had the SBR of over 100‰ both in 1933 and 1938. The fact that the high SBRn the villages near the mine may also suggest that the mining pollution give negative effects on the stillbirth.

Fig. 1 Akita Prefecture in Japan and the Yoneshiro River and mines.

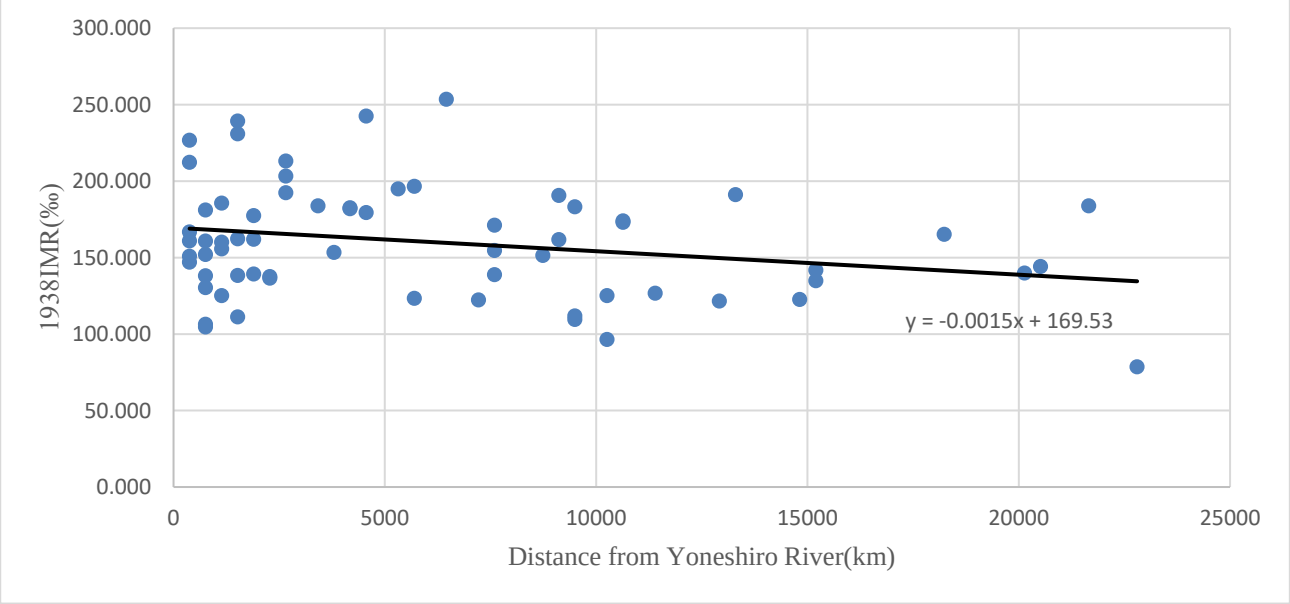

Fig. 2 Scatterplot of IMR and distance from the Yoneshiro River.

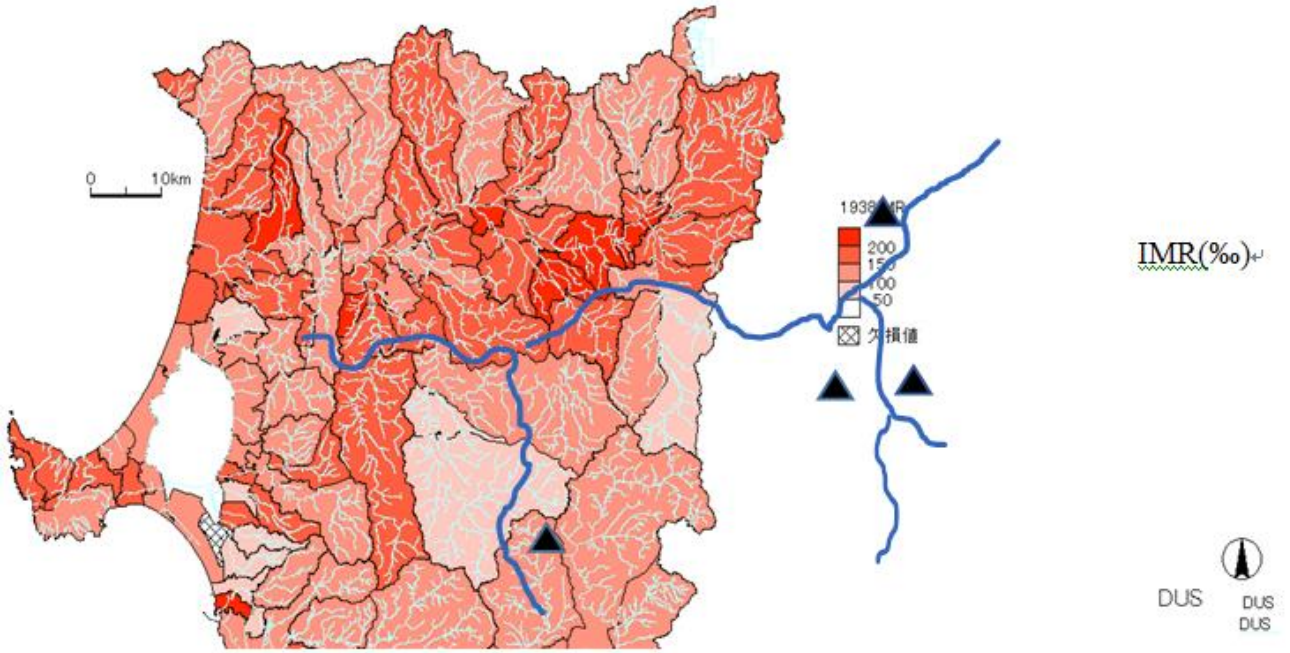

Fig. 3 IMR around the Yoneshiro River.

Table 1 IMR and distance from the Yoneshiro River.

IMR	t
Distance from the Yoneshiro River	-2.046※
F-statistic	4.188
R-squared	0.062
observations	65

Regression Analysis (IMR)

※=Significant at the 5 percent level

Table 2 SBR and distance from the Yoneshiro River.

SBR	t
Distance from the Yoneshiro River	-0.575
F-statistic	0.331
R-squared	0.005
observations	65

5. Conclusion

This paper clarified the relationship between environmental pollution, especially mining pollution and infant mortality in Japan in the 1930s. Around the Yoneshiro River, in Akita Prefecture, heavy metals accumulated in the mother's body due to rivers contaminated with mining pollution, which was responsible for the high IMR. Moreover, it was not clarified by the regression analysis, the high SBR was recorded in the villages near the mines, suggesting that the mining pollution give negative effects on the stillbirth. However, the IMR is not only related to environmental pollution, but also is related to nutrition, the local medical situation and the local historical background. So in the future, we would like to expand the case analysis to the whole of Japan and to analyze relationship between the IMR and the other factors.

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