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Tracers: A Powerful Tool for Verifying Flowmeters and Water Balance in Mineral Processing Operations

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Introduction

Los Pelambres Mine is located at the IV Region of Chile, semiarid region, where water resources plays a key role as it is a scarce resource and vital for the sustainability of human life, animals and ecosystem.

This is why water is considered a strategic resource for MLP and a need to have a reliable water balance is becoming urgent.

Tracers to measure flux and fluid velocity

Conventional flow meters installed in pipes may suffer disruptions or failures due to corrosion, fouling, presence of elements in the water such as acids, salts and suspended solids. Radiotracers use is advantageous, to determine flux and fluid velocities of liquids and solutions transported by pipelines, compared to other methods.

Objetive

The objective in this work is to characterize hydraulic behavior of the recirculation pumping stations of industrial water at the mine, in order to have a reliable mass balance of water considering the feeding systems, the pumping stations and the water recirculation channels. For this, to measure speeds and lift flow in each pipe and piping station. Also we measure flow rate in the courses of rivers or superficial waters feeding systems

METHODOLOGY

Flow speed on pipes

Flow rate measurement by the transit time method is based on measuring the transit time of labelled fluid particles between two cross-sections of the pipe at a known distance. Labelling of the fluid particles is achieved by injecting a tracer into the flow upstream, then, the transit time is determined from the difference of the mean arrival times of the tracer at each of the detector positions located at two different cross-sections of the pipe, were the detectors are installed

Flow speed on pipes

Due to the excellent physicochemical dissolution in water I-131 is used as radiotracer, with activities between 5 and 50 mCi; halftime life is appropriate, considering the transportation time to the mine, and experiences duration (8 days); finally, the radiation energy of the I-131, allows us the detection through thick steel pipes.

The fluid speed is determined using the transit times between 2 or more detectors; therefore it is convenient that the entrance of the tracer to the system be as close as possible to a pulse. The tracer is injected close to the suction of a pump that lifts the process water.

Radioactive Tracer Injection

Radioactive Tracer Detection

Superficial flow

The methodology consists in the continuous injection in the course of superficial water of a fluorescent tracer, Rhodamine WT, of $\mathbf{C_q}$ concentration to a constant flow **q.** Waters below the range of good mix, the tracer takes a constant value of $\mathbf{C_Q}$ concentration. If we call **Q** the stream flow we are interested in measuring, we have the following equation.

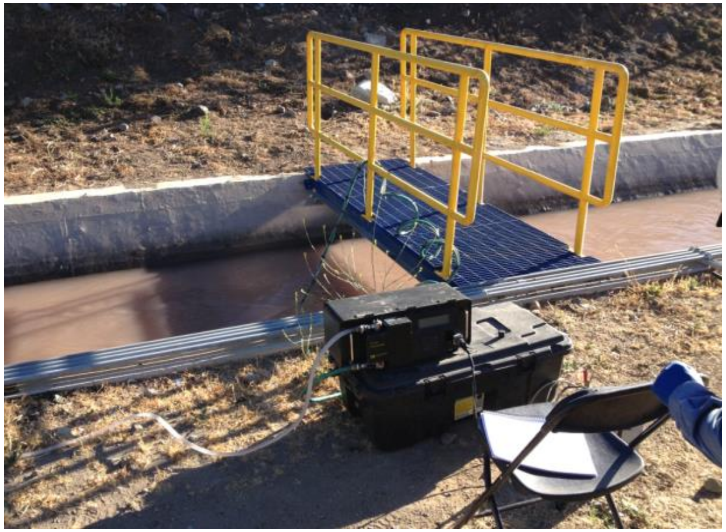
$$Q = \left({}^{C_q}\!/_{C_Q} \right) * q$$

Superficial flow

For superficial water courses it is used Rhodamine WT because it can be detected in very low levels (parts by billion), therefore only some grams of this tracer are needed. The dilution is done continuously at the same water course. The amount of Rhodamine WT is calculated depending on the known flow of the water course.

Fluorescent Tracer Injection

Fluorescent Tracer Detection



RESULTS

Flow speed in pipes

The data acquired through instrumentation on line are corrected by emission decay and by natural background. The mathematical expression (Atomic Energy International Agency, 1990) that summarizes the calculation of radiation intensity is:

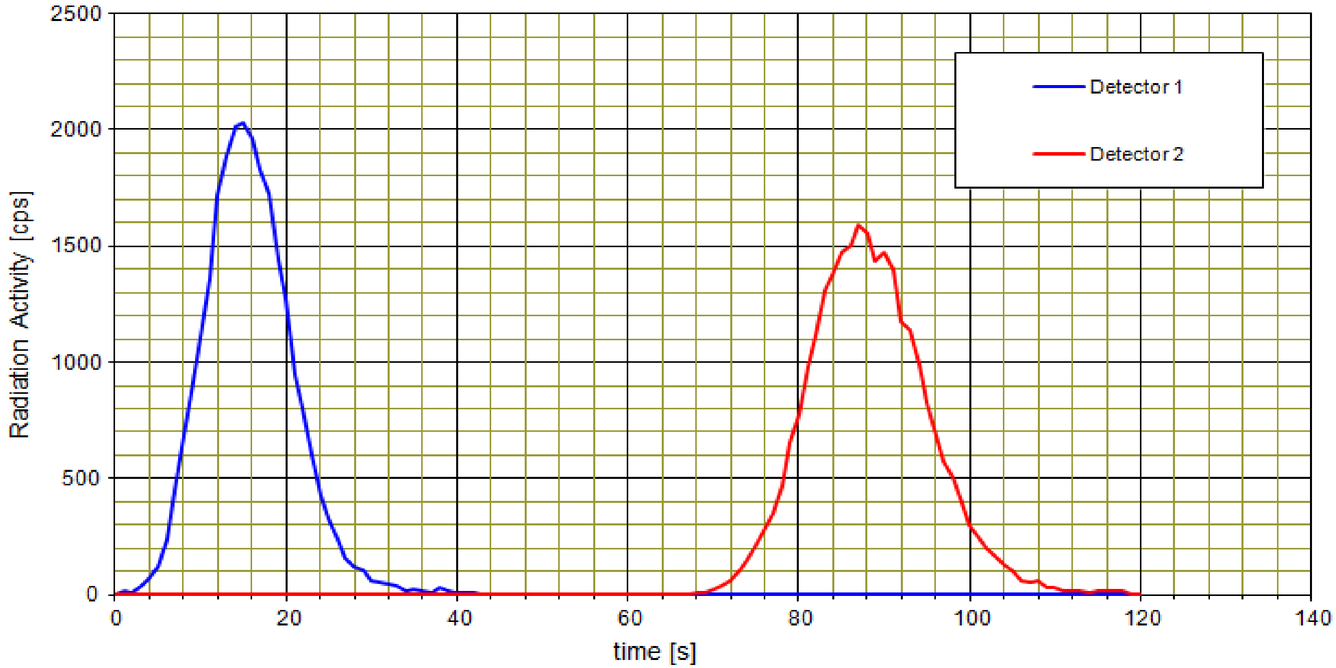
$$A_{cor} = (A_{med} - BG) * e^{\left(0.693 * t / t_{1/2}\right)}$$

Flow speed in pipes

To get the flow rate it is necessary to obtain the experimental half residence time of each “Distribution Residence Time Distribution Curve”, applying the moments method, as follows:

$$t_{exp} = \frac{\int_0^\infty t * A_{cor}(t)dt}{\int_0^\infty A_{cor}(t)dt}$$

Flow speed in pipes



Transit time in Choapa 2 with two pump oprating

Average flow speeds in lift stations

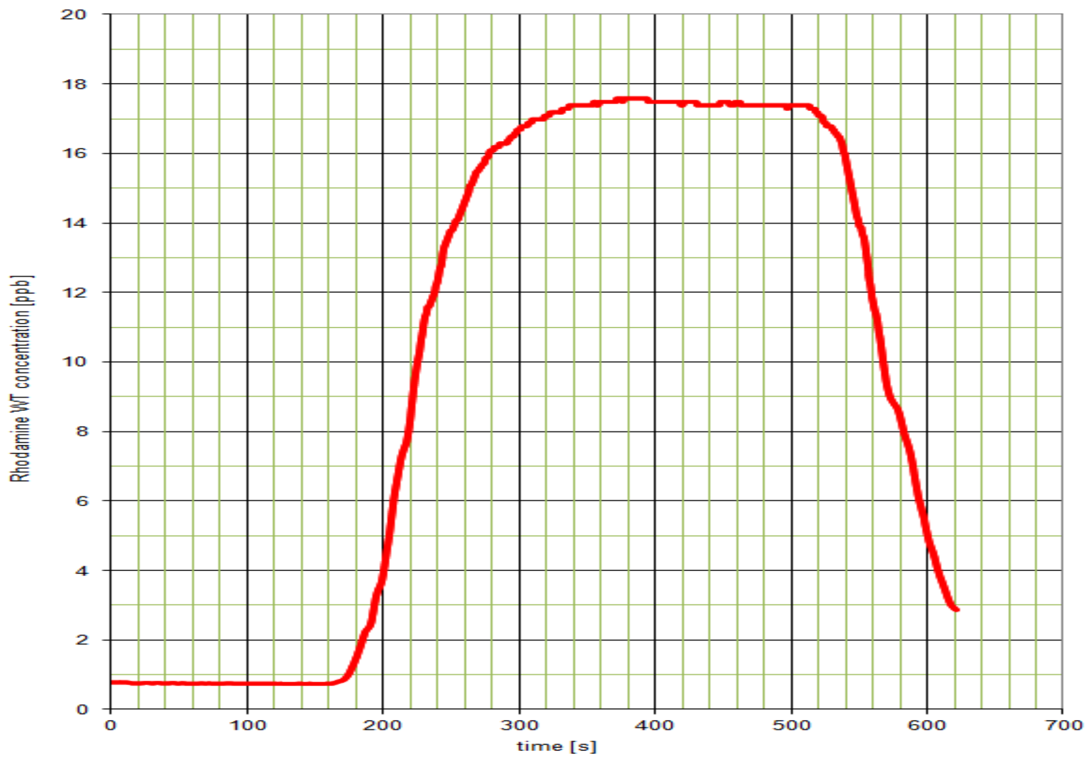
Pumping station	Flow Condition	Average flow rate [m/s]	Standard Deviation [±]
Choapa 1	One pump operating	0,90	0,01
Choapa 2	Three pumps operating	1,72	0,01
Choapa 3	Two pumps operating	1,88	0,01
Drains Quillayes	One pump operating	0,41	0,01
Fija a Planta	One pump operating	0,47	0,01
R2	Five pumps operating	2,22	0,08
TK052	Six pumps operating	2,49	0,05
Ventana Dos	Only gravity	0,77	0,01
Drains El Mauro	One pump operating	0,56	0,01
R1 (El Mauro)	Three pumps operating	1,58	0,02
Intermedia hacia R1	Six pumps operating	1,76	0,04
Intermedia hacia TK14	Five pumps operating	1,08	0,05

Flow speed in pipes

Flow comparison by measurements with tracers and flowemters online

Pumping Station [-]	Nº of operating pumps [-]	Flowmeter [L/s]	Flow with tracers [L/s]
Choapa 1	1	232	217
Choapa 1	2	385	335
Choapa 1	3	467	412
Drain El Mauro	1	79	102
Drain El Mauro	2	164	207
Drain El Mauro	3	224	278

Water flows in superficial water courses



Rhodamine WT concentration vs Time

Water flow rate in captation superficial water courses

Water course	Flow rate [lts/s]
Pelambres river	114.5
Piuquenes river	58
Drain Quillayes	89.5
Bocatoma Choapa	271
Drain El Mauro	166.8

CONCLUSION

The methodology used and experimental arrangments, were appropiate to provide a good answer to the requirements. Measures demonstrate deviations ranging from -6,9% up to +22.5%.

The differences of flow rate between the online instrumentation and what we obtained through the use of tracers are considered “important”, therefore they will be used for validation or correction of the given information by the flowmeters. Due to the obtained “hard datas”, the appropriate control of the hydric resourse as a operation livelihood of mineral processing, are possible.

ACKNOWLEDGEMENTS

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