Water quality indicators as a tool for adoption of progressive objectives in São Paulo State

Claudia Bittencourt

São Paulo State Sanitation and Water Resources Secretariat, FMU University, São Paulo, Brazil

cbittencourt@ssrh.sp.gov.br

***Abstract*-**In the 1970s, São Paulo State defined qualitative frameworks for its water resources based on main economic activities to be developed on rivers basins. Sometimes objectives are too far from the actual moment, and that temporal dimension horizons can be better defined on participative and technical basis. Actually is being studied a criteria to subsidize delimitation of intermediary objectives that supports the planning process to be continuously developed on a more intensive progressive perspective. Once the planning have being elaborated on a participative foundation among municipalities, State government and society, a criteria approved by the stakeholders can help on reducing the natural conflicts when stablishing planning products. The proposal presented in the actual paper was approved preliminarily and is submitted to further studies actually.

***Keywords*-** *Water Resources; Quality Indicators; Progressive Objectives*

I. INTRODUCTION

Quality indexes developed and calculated periodically by São Paulo State Environmental Authority (Cetesb) are used for long time to evaluate the water quality of the state rivers and reservoirs.

Detecting quality indexes as having good or bad evaluation, on planning environment is not enough. Waters in the State are disposed on a large complexity of elements as metropolitan areas, agriculture sites and in a very large territory. That complexity is better managed with a criterion that subsidizes the management system on developing priorities. What is offered and presented in this paper is a quality based general criteria that improve existing ones concerning progressiveness.

Products obtained by criteria utilization also intent to help on the improvement of sectorial and regional municipal and state plans as also being helped by them.

Indexes also are vulnerable to questions beyond average plans as irregular land use and extreme scarcity or flood periods. These issues need to have its impacts dimensioned, so the input in water resources plan or the relationship with other plans is adjusted considering scenarios.

The following proposal considers that São Paulo State Water Resources Management Units are autonomous on its management. It considers also that State instance for management is an observatory that has as function to follow the entire State unit and to identify and monitor issues over Water Resources Management Units. The information obtained from that observatory is offered in addition to a compilation of Water Resources Management Units plans as São Paulo State Situation Report which subsidizes São Paulo State Water Resources Plan [1].

The management instruments of Water Resources Management Systems is based on charging for water use, quality framing of water resources, concession of water resources, Water Resources Situation State Report, Water Resources State Plan and Water Resources Management Units Plans [1, 13].

II. SÃO PAULO STATE CHARACTERISTICS

São Paulo State has an approximate population of 44,749,699 inhabitants [1] which represents 22% of Brazil population. Its location is presented in Fig. 1.

State	Symbol
Rondônia	RO
Acre	AC
Amazonas	AM
Roraima	RR
Pará	PA
Amapá	AP
Tocantins	TO
Maranhão	MA
Piauí	PI
Ceará	CE
Rio Grande do Norte	RN
Paraíba	PB
Pernambuco	PE
Alagoas	AL
Sergipe	SE
Bahia	BA
Minas Gerais	MG
Espírito Santo	ES
Rio de Janeiro	RJ
São Paulo	SP

Fig. 1 São Paulo State location in Brazil (IBGE)

DOI:10.5963/JWRHE0603003

State area corresponds to 248 million $km^{2.}$ It means that managing São Paulo State conflicts is almost managing some countries issues.

Social Responsibility Indicator is calculated concerning municipality richness (economic indicator), population longevity and schooling (social indicators) dimensions [1].

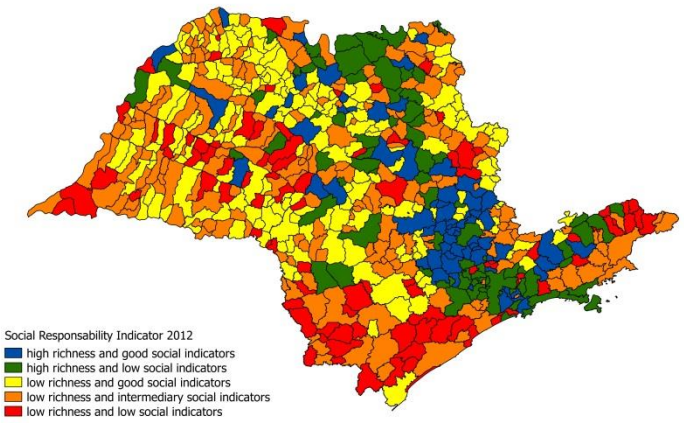

Fig. 2 São Paulo State Social Responsibility Indicator 2012 (IBGE)

Fig. 2 pictures São Paulo State socioeconomic heterogeneity by municipality considering social responsibility indicator. It is important to understand because different scenarios require different approaches.

It is important to observe that there is a close relationship between social indexes and sanitation facilities availability [2].

Sustainability of sanitation services offer and maintenance depends on a management model that consider social issues on its planning by offering sanitation structures for a part of population that is economically and socially vulnerable [3]. Once it is not possible to offer to all population sanitation structure at once, sanitation plans are being developed, according Law 11.445/2007 [4] providing temporal horizons for sanitation universalization.

São Paulo State Sanitation Company develop sanitation infrastructure for approximately a half of São Paulo State municipalities and operates subsidy among consumption classes and also between regions, to allow that regional management reduces municipalities differences making sanitation market closer to an ideal sustainable model [3].

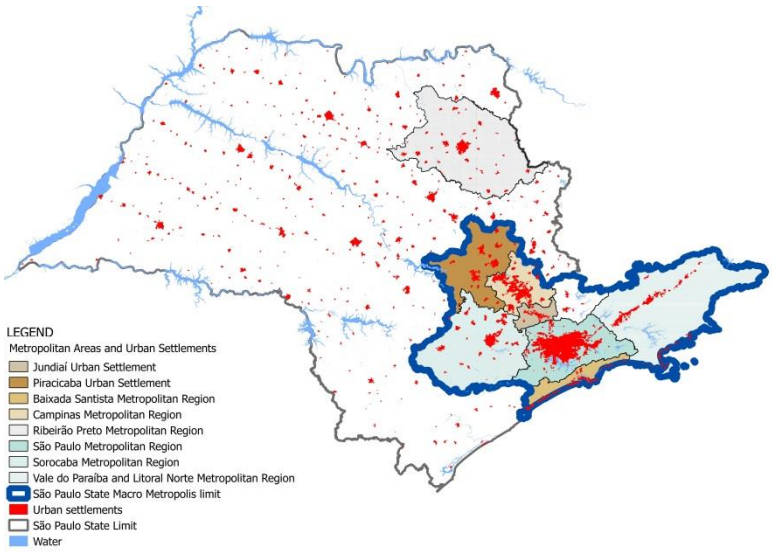

Fig. 3 São Paulo State Urban areas distribution 2012 (Emplasa, ANA, IBGE, IG, DATAGEO)

DOI:10.5963/JWRHE0603003

Population distribution is also asymmetric and the largest conurbation corresponds to a group of metropolitan areas called Macro Metropolis (Fig. 3). São Paulo City Metropolitan Area concentrates 18% of Country gross domestic product [12].

Conurbations under the water resources management perspectives means that even with an temporal horizon to offer sanitation infrastructure to regular areas, pollution concentration mean managing socioeconomic questions as well, which increases that complexity.

III. WATER RESOURCES MANAGEMENT IN SÃO PAULO STATE

Conceptual quality framework defined by law [5-6] consider a party of mentioned complexity and define for rivers and reservoirs classes of use considering the most noble main activities developed on river basins.

Brazilian water resources management model before 1970s had its focus on energy sector. Sanitation was at that time related to housing policies and was not articulated with water resources quality aspects needs [7].

Surface waters are classified in 5 classes, Special (should not have their natural conditions altered), Class 1 (domestic supply, Class 2 (domestic supply, bathing aquatic communities protection), Class 3 (boating, fishing) e Class 4 (navigation).

A. Quality Indexes

1) IQA – Water Quality Index

IQA-Water Quality Index is used to evaluate waters destined for public provision. Index calculation is based on dissolved oxygen, biochemical oxygen demand, pH, turbidity, fecal coliform, total phosphorus, total nitrogen, total solids and temperature. The water temperature is IQA variable assumed as constant and equal to maximum quality, 92.5%. Measured values are transformed on a percent quality by a normalizing function composed by many least square approximations defined by CETESB, according to variable characteristics, which varies for different sub-intervals [8].

Spatial representation for IQA in São Paulo State in 2015 is shown in Fig. 4 [9].

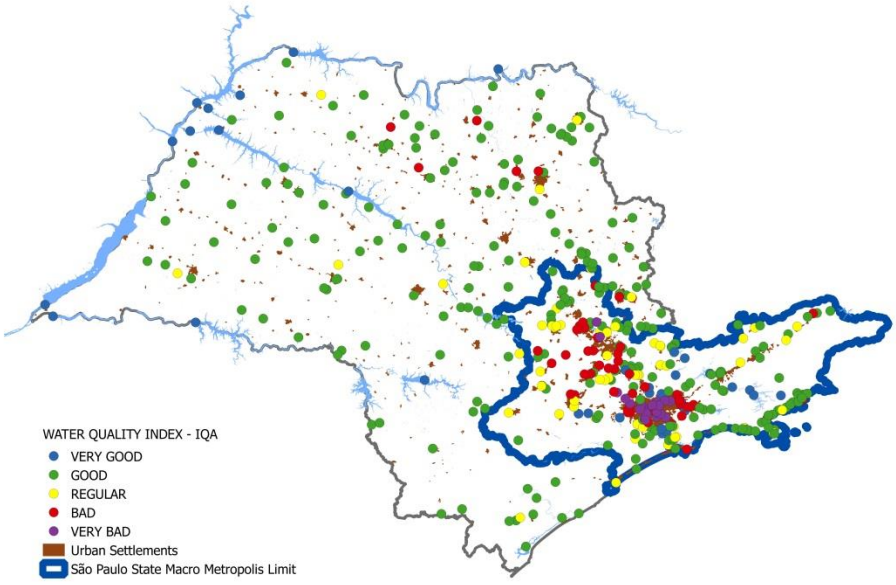

Fig. 4 IQA spatial representation – 2015

The relation among water quality and population density is observed when comparing Figs. 2, 3 and 4. The agricultural activities offer less impact when IQA is adopted as evaluation parameter. The areas were more attention is required, is mostly classified on Class 4, which means, water quality desirable for navigation.

The classification criteria is also connected to participative management system and due to fundament analysis developed on instances of management system the classification can be changed.

2) IAP - Row Water Quality Index for Public Water Supply

Row Water Quality Index for Public Water Supply (IAP) is calculated as a product of IQA and Toxic and Organoleptic Substances Index (IAP) [9].

Spatial representation of IAP is presented in Fig. 5.

DOI:10.5963/JWRHE0603003

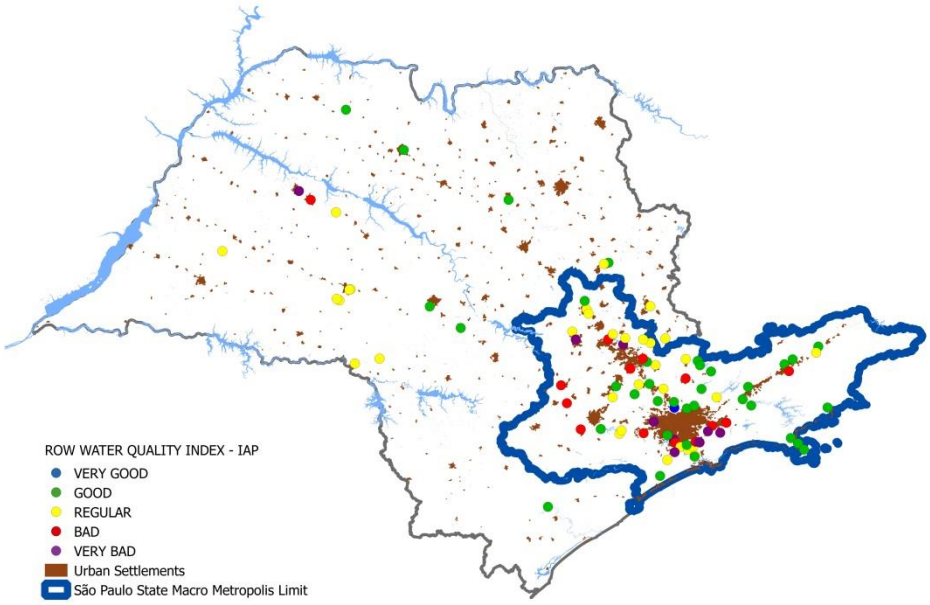

Fig. 5 IAP spatial representation - 2015

At west area of São Paulo State, groundwater is largely used.

Bad and very bad points are observed more because of water scarcity effect. Treatment technologies were adapted to provide potable water.

3) IET - Trophic State and IVA - Aquatic Life Index

IET classify water bodies on different trophic levels while IVA evaluates water quality considering aquatic life preservation [9].

Those indexes are considered by Quality Authority but on planning environment are about to help on priorities classification.

As a matter of fact, with a practical view, we believe that punctual action of Quality Authority will control IVA while other criteria are subsidizing plans orientation.

B. Quality Indexes Resignification

The proposal consists on, considering quality goals represented by surface water classification, submit IQA index to a perspective of progressive approach to help planning and execution control in São Paulo State quality water resources management. Sanitation offer and also urban development are related programs that direct interfere on quality development. Brazilian Sanitation Systems Law stablishes progressiveness in offering sanitation infrastructure respecting economic conditions and tariffs moderateness [4].

A ranking criteria considering mentioned indexes can be represented by Fig. 6 were the evolution of restrictiveness is presented as a support for progressive goals on future plans [10].

DOI:10.5963/JWRHE0603003

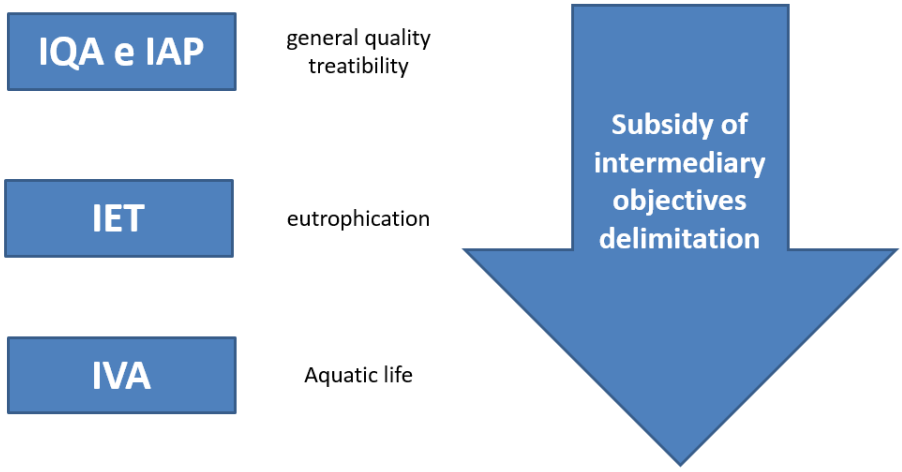

Fig. 6 Proposed indexes ranking and relation with the type of control performed by each indicator

Once IQA e IAP figure on top of priorities, and because IQA is calculated on a more specific perspective considering IQA and toxicity concerning public water supply, only IQA was associate to Law parameters.

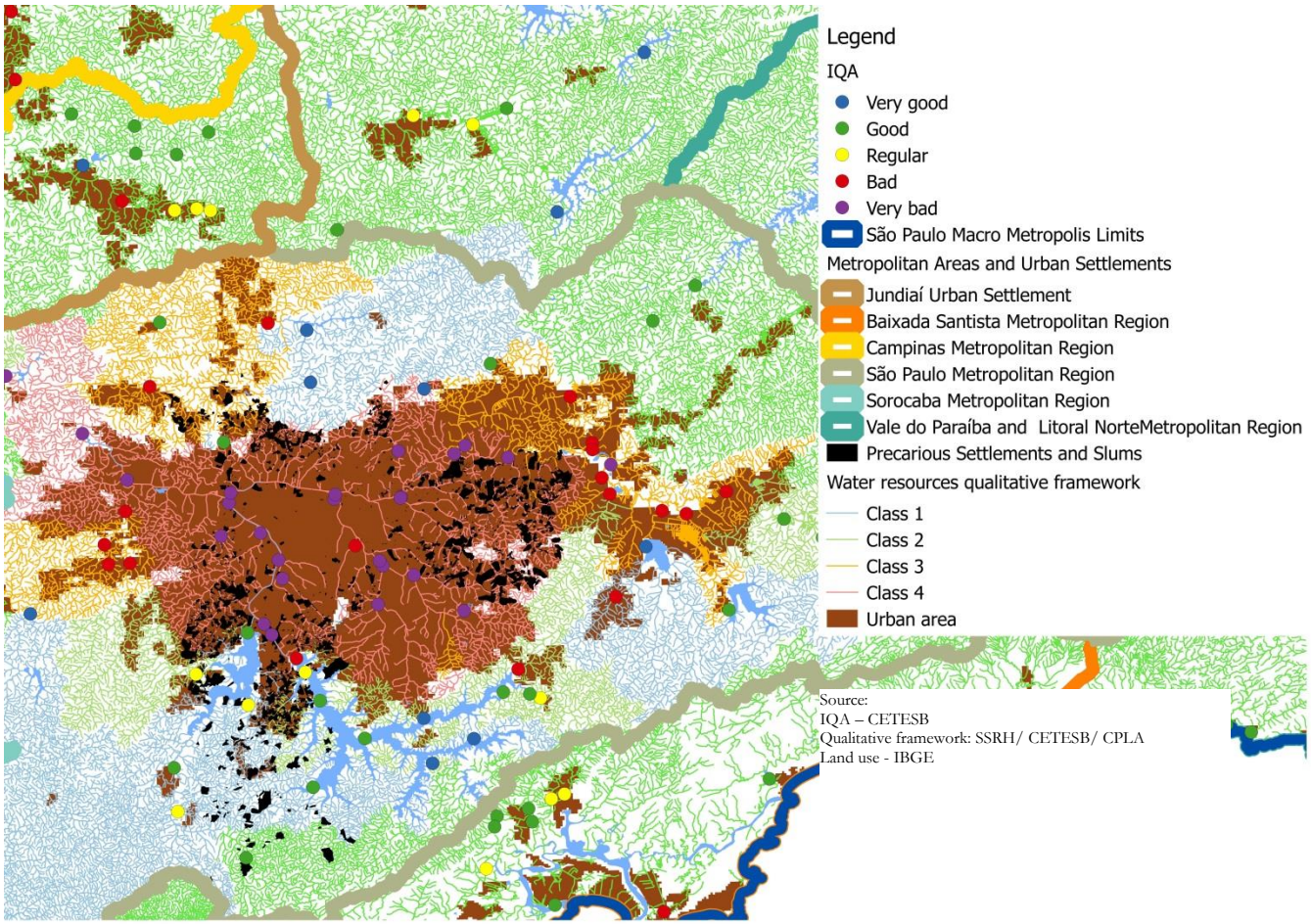

Fig. 7 Water body classification and water quality (IQA)[10] Development and design: Renata Cristina Oliveira

Fig. 7 helps the understanding of correlation between rivers classification (quality framework classs) and quality actual indexes. Meanwhile, actions on the participative water management system can reclassify rivers acordding to discussions and needs.

DOI:10.5963/JWRHE0603003

IV. CONCLUSION

The crescent complexity of urban conurbations and the fact that management of water resources is a participative process make Water Resources Management System a forum to conflicts management.

Complex Systems are possibly simplified by adoption of simpler models as proposed one [11].

The proposed criterion consists first on ranking the actual quality key performance indicators that are regularly produced by water regulation authority [10]. Secondly, the association of main indicators with the qualitative framework set by law [1, 5-6] and regulation [14].

The proposed ranking helps a structuration of a coordinated action between sanitation infrastructure and progressiveness of quality standards on temporal basis.

Land use dynamics understanding plays an important paper on interpreting quality indexes, especially on conurbated regions.

Policy Power activities differ from the ones of planning environment and that fact justify the existence of a correlation that helps the use of indexes generated by Quality Authority transposing it to planning environment.

REFERENCES

[1] Brazil, Law No. 9.433/1997. Stablishes Water Resources National Policy. [Online]. Available: http://www.planalto.gov.br/ccivil_03/Leis/L9433.htm. [Access 08 25 2016].

[2] P. A. C. Libânio, C. A. D. L. Chernicharo, and N. D. O. Nascimento, "The Waters Quality Dimension: Evaluation of relation between social water availability sanitation and public health indicators," *Sanitary and Environmental Engineering Specialist Periodical*, 2005.

[3] C. Bittencourt and E. B. Furlan, "Regulation of Sanitation Services," in *Brazilian Regulation Agencies*, 2014. ISBN 978-85-8238-184-7.

[4] Brazil, Law No. 11.445/2007 - Stablishes National Orientation for Basic Sanitation. 05 01 2007. [Online]. Available: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/l11445.htm. [Access: 31 07 2017].

[5] São Paulo, State Decree 8.468/1776. Approves of Law number 997/1976. Stablishes environmental pollution prevention and control [Online]. Available: http://www.al.sp.gov.br/repositorio/legislacao/decreto/1976/decreto-8468-08.09.1976.html. [Access 0 05 2016].

[6] São Paulo, State Decree number No. 10.755/1977. Stablishes water resources framework considering. Decree number 8.468/1776. [Online]. Available: http://www.al.sp.gov.br/norma/?id=153028. [Access 08 08 2016].

[7] H. R. Muñoz, *Water Resources Management Interfaces Challenges of 1997 Law of Waters*, Brasília: Brazilian Environment Ministry, United Nations, BIRD, 2000.

[8] G. S. Ragazzo and J. S. Bevilacqua, "Applied and Computational Math Southeast Congress Annais" (2013) [Online]. Available: http://www.sbmac.org.br/cmacs/cmac-se/2013/trabalhos/PDF/6750.pdf.

[9] Cetesb, São Paulo State Surface Waters Quality Part 1 - Spring Waters, São Paulo Cetesb. SMA. 2015 [Online]. Available: http://www.cetesb.sp.gov.br/agua/aguas-superficiais/35-publicacoes. [Access: 02 08 2016].

[10] São Paulo. *Water Resources State of Affairs Report 2015*, São Paulo State Water Resources Secretariat, Water Resources Coordination. 6th ed., São Paulo. ISBN 978-85-65214-08.

[11] U. Sekaran and R. Bougie, *Research Methods for Business: A skill-building approach*, Wiley, 2013.

[12] Emplasa, São Paulo State Metropolitan Planning Company, EMPLASA (Empresa Paulista de Planejamento Metropolitano), São Paulo, 2010.

[13] São Paulo, São Paulo State Decree No. 27.576/1987 - Stablishes Water Resources São Paulo State Council, Stablishes Water Resources State Plan and São Paulo State Water Resources Management System.

[14] Brasil, National Environmental Council Determination No. 357/2005 - Stablishes water resource classification and orientation concerning a qualitative framework, as well the establishment of standards for and conditions for disposal of effluents. 03 17 2005. [Online]. Available: http://www.mma.gov.br/port/conama/res/res05/res35705.pdf. [Access: 25 08 2016].

Claudia Bittencourt is a worker of São Paulo State Sanitation and Water Resources Secretariat and a Specialist Professor of FMU University where she teaches in specialization and graduation courses. A graduated Chemical Engineer is a Specialist by São Paulo State University on Pollution Control Engineering and Specialist on Wastewater Treatment at TUHH/ Germany. Actually she is a student of Doctoral program of São Paulo State University on Nuclear Energy on Environment studies.

Claudia is author of the books "Water and Effluents Treatment" and "Regulation Agencies in Brazil" (Chapter). She works as consultant for third sector on sustainable development enterprises voluntarily.

DOI:10.5963/JWRHE0603003