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Original Research Paper

Analysis of Water Quality Index (WQI) in Dalvoy Lake, Mysore City, India

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ABSTRACT

The Dalvoy lake of Mysore is fed mostly by storm water drainage from a major part of the city. It is exposed to the influence of heavy urbanization and industrialization. The lake water is primarily used for agricultural practices seen over the southeastern side of the lake at downstream end. Due to several reasons, the water quality is deteriorating. In order to evaluate the potability and assessment of water quality for different purposes, all important physicochemical and biological parameters were detected by collecting samples from the surface and also from depths ranging from 4 to 12 feet. The water analysis data were processed to determine the water quality index by NSF method. For each of WQI a descriptive quality indicator has been derived as very poor (0-38), poor (39-71), good (72-83), very good (84-89) and excellent (90-100) categories. Surface water quality, mainly used for drinking water abstraction, has been represented on the lake network map. In this paper the water quality indicators were calculated for all locations and also classified with reference to seasons. It was observed that the WQI of the Dalvoy lake is not good and the main cause of deterioration is due to the lack of proper sanitation, untreated inflow water with municipal sewage and due to uncontrolled anthropogenic activities.

INTRODUCTION

The chemical pollutants of industrial, domestic and agricultural origin find their way into lakes through surface runoff and precipitation and increase the level of pollutants (Yalcin & Sevinc 2001). Since 1965, when Horton (1965) proposed the first water quality index (WQI), a great deal of consideration has been devoted to the classification of ‘water quality index’ to various water bodies. Landwehr (1979) points out that an index is a performance measurement that aggregates information into a usable form, which reflects the composite influence of significant physical, chemical and biological parameters of water quality conditions.

Water Quality Index (WQI) is one of the most effective tools to communicate information on the quality of water to concerned citizens and policy makers (WHO 1993, APHA 1994). The following four steps, parameter selection, transformation of the parameters of different units and dimensions to a common scale, assignment of weightages to all the parameters, and aggregation of sub-indices to produce a final index score are the most often associated with the development of any WQI depending on the sophistication being aimed at, additional steps may also be taken (Otto 1978, Abbasi 2002, Pielou 1977, Prati et al. 1971, Ramakrishnaiah et al. 2009, Schaeffer et al. 1977).

The advantages of indices include their ability to represent measurements of a variety of variables in a single number, the ability to combine various measurements in a variety of different measurement units in a single metric, and the facilitation of communication of the results. Disadvantages include the loss of information on single variables, the sensitivity of the results to the formulation of the index, the loss of information on interactions between variables, and the lack of potability of the index to different ecosystem types (Zandbergen & Hall 1998). WQI was the intent of providing a tool for simplifying the reporting of water quality data (Liou et al. 2003). The computer automated tool QUALIDEX (waterQUALIty inDEX), which has been developed (Chinmoy Sarkar & Abbasi 2006) to generate and operate water quality indices. Once the WQI are developed and applied, they serve as convenient tools to examine trends, to highlight specific environmental conditions, and to help governmental decision-makers in evaluating the effectiveness of regulatory programmes (Kumaraswamy 1999, Otto 1978).

Hence, there are several reports on river water quality assessment using physico-chemical and biological parameters (Madhyastha et al. 1999, Santosh et al. 2007). The WQI approach has many variants in the literature, and comparative evaluations have been undertaken (e.g., SDD 1976, Otto 1978, Dunnette 1979, Miller et al. 1986, Smith 1990, Cude 2001). Different water quality parameters are expressed in different units. Some index scales have the range 0-100. The water quality index is a unitless, single dimensional number between 0 and 100.

Therefore, a numerical index is used as a management tool in water quality assessment. Until recently, the Dalvoy lake has not been subjected to water quality evaluation using water quality indices. In the study, the physicochemical characteristics of the water samples have been estimated using ISI (1991) methods, and evaluated the water quality index NSF International, formerly the National Sanitation Foundation. According to the ***Field Manual for Water Quality Monitoring***, the National Sanitation Foundation surveyed 142 people representing a wide range of positions at the local, state, and national level about 35 water quality tests for possible inclusion in an index. Nine factors were chosen and some were judged more important than others, so a weighted mean is used to combine the values.

The WQI evaluates the value of each water quality parameter relative to its objective value. WQI is based on some important parameters that can provide a simple indicator of water quality. It gives the public a general idea of the possible problems with water in a particular region. Nine parameters were taken for WQI calculation, namely DO, FC, pH, turbidity, TS, nitrates, phosphate, ΔT and BOD (Tables 3, 4, 5). The WQI calculation was carried out with the following equation as described by Bhargava (1983), Raczynska et al. (2000).

Water Quality Index: $(WQI) = \frac{\sum_{i=1}^{n} Wi\,Qi}{\Sigma\,Vi} (WQI) = \frac{\sum_{i=1}^{n} Wi\,Qi}{\Sigma\,Vi}$

Where, Q_i (Water quality rating), V_i = ideal value of one parameter in pure, i th parameter, Weight factor (W_i) = Unit weight for the i th parameter ($W_i = K/S_n$), where, K (constant for proportionality) = $1/(1/V_{s1} + 1/V_{s2} \ldots + 1/V_{sn})$, S_n = standard value of WHO for i th parameter.

STUDY AREA

Dalvoy lake was constructed during the period of Maharaja's of Mysore (19th century) to fulfil the needs like water supply for drinking, irrigation, industries and other related works. This lake is located 5 km south of Mysore city. This lake can be located in the toposheets No. 57 D/11/6 and 57 D/12/NE at 12°15' latitude and 76°39' E longitude (Figs.1, 2). The total catchment area of the lake is 2615.00 acres covering Dalvoy series, Shettykere, Marshy pickup, Sakamma pickup and Gudumadanahally pickup. The main source of water to the lake is rainfall, urban runoff from the

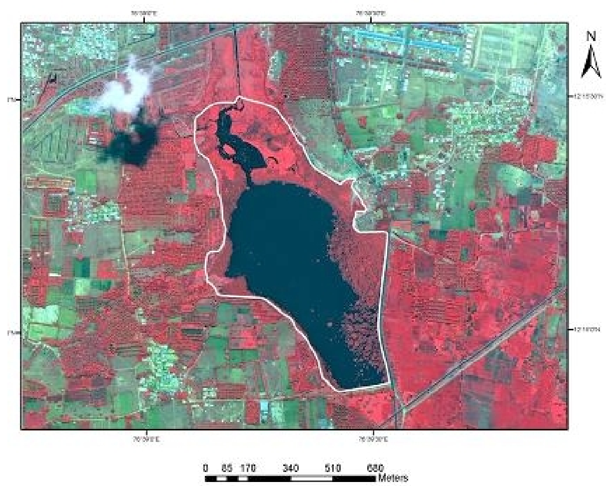

Fig. 1: Satellite image of the Dalvoy Lake.

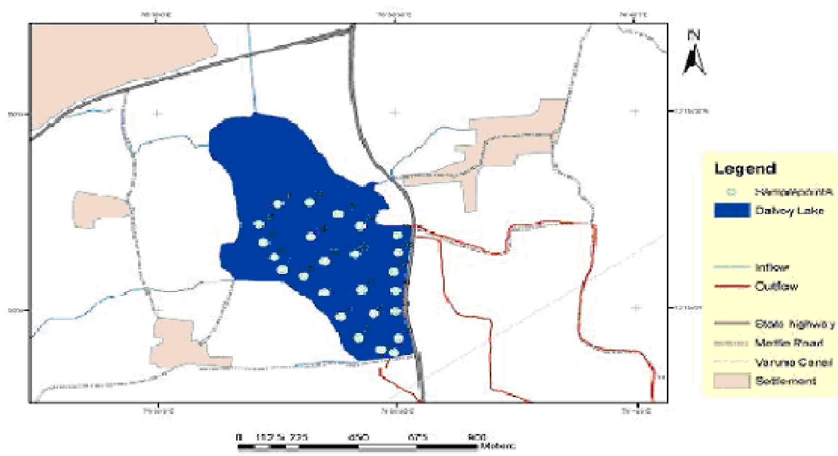

Fig. 2: Location of sampling sites in Dalvoy Lake, Mysore city, India.

elevated areas through storm water drains, sewage water from Mysore city and also the irrigation return flow from D.D. Urs (Varuna) canal distributaries (Table 1).

MATERIALS AND METHODS

The sampling sites were selected by keeping in mind the locations of inflow and outflow. Water samples were collected from the surface and few meters below water level to find out the varying characteristics, if any, of surface and bottom waters, by using specially designed airtight sampler, using clean and sterile polythene bottles. GPS receiver was used to record the exact location. Water temperature and dissolved oxygen were recorded on the site of sampling. The samples were preserved and further analysed. Based on NSF method, the WQI was determined. It gives the interpretation of water quality based on water chemistry, biology, suitability and usage factors like potability or corrosively.

Table 1: Physical profile of the Dalvoy lake.

Sl. No.	Description	Details
1	District	Bandipalya village/Mysore taluk/Mysore
2	Location: Longitude and Latitude	76°39'0" E/12°15'0" N
3	Total extent of the catchment	15.46 sq.mile
4	Average Annual Rainfall	32" (819.20 mm)
5	Monsoon Rainfall	29.76" (762.00 mm)
6	Water spread area	54 hec
7	Gross storage	30 Mcft.
8	Maximum flood discharge	190.00 Cusec.
9	Irrigable area	145.30 hec
10	Length and atchkat of RBC	L = 2.7 m
11	Length and atchkat of LBC	L = 0.7 km
12	Number of fillings	Full throughout the year

RESULTS AND DISCUSSION

From the results of the analysis (Tables 3, 4), it could be seen that the total solids in this lake range between 748 to 842 mg/L in both pre and postmonsoon seasons. The water temperature of lakes is very important, as many of the physical, biological and chemical characteristics of lakes are directly affected by temperature. Most waterborne animal and plant life survives within a certain range of water temperatures, and few of them can tolerate extreme changes in this parameter. The lake temperature ranged between 21.3 to 25.9°C in pre monsoon and 21.5 to 23.7°C in post monsoon seasons. Phosphate (PO_4^{3-}) is readily taken by phytoplankton, and it is necessary for plant and animal growth. It can be present in water in many forms, so total phosphate gives an estimate of the total amount of phosphorus potentially available in a given water supply. It varied in the lake from 5.6 to 9.8 mg/L in premonsoon, and 5.6 to 9.3 mg/L in postmonsoon seasons. Higher value of phosphate in lake water is due to agricultural wastes and use of fertilizers.

The common source of nitrate are the fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plant debris. Water naturally contains less than 1 mg of nitrate-N per litre. Higher levels indicate that the water has been contaminated. The nitrate in the lake ranged between 13 to 28 mg/L in premonsoon and 13 to 25 mg/L in postmonsoon seasons. The dissolved oxygen test measures the amount of life-sustaining oxygen dissolved in the water. This oxygen is available for fishes, invertebrates and all other aquatic animals. Most aquatic plants and animals need oxygen to survive. Depletion of DO in water is due to high temperature or adding some organic materials, which increase microbial activity (Kataria et al. 1996). In Dalvoy lake, the dissolved oxygen ranged between 1 and 8.6 mg/L in premonsoon and 1 to 6.4 mg/L in postmonsoon seasons. Sedimentation of suspended solids can cause buildup of decomposing organic matter in sediments and dissolved NH_3 can contribute oxygen depletion due to nitrification. Low level of dissolved oxygen is a sign of possible pollution. Therefore, DO is one of the important parameters in calculating water quality index. In the present study, it varied from 1.85 mg/L at PR06S19 station to a maximum of 8.6 mg/L at PR06S16. The biochemical oxygen demand (BOD) is a measure of the amount of biological pollutions and the values ranged from 1 to 21.3 mg/L in both pre and postmonsoon seasons. Naturally, bacteria utilize organic matter in their respiration and remove oxygen from the water. The BOD test provides an estimate

Table 2: Water quality index.

Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

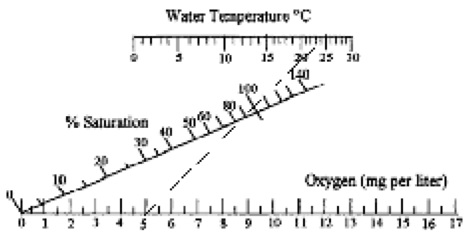

Fig. 4: Nomogram for calculating oxygen saturation.

of how much biodegradable material is present in the water. The lake water is used for agriculture, fisheries and washing automobiles. Extensive growths of water hyacinth and other hydrophytes is noticed during summer, which is collected and used for various purposes.

For calculation of WQI, Q value was calculated for each parameter. The Q value for each test was multiplied by the weight factor (Bhargava 1983) and the results are given in Table 5. The weight factor indicates the importance of each test to overall water quality. In order to interpret the water quality at Dalvoy lake, the WQI (W_iQ_i) at average stations was compared with the Index to rate the quality of water by giving the scale from 0 to 100 (Table 2). Water Quality rating (Q_i) equal to 100 means complete absence of pollutants, while $0 < Q_i < 100$ implies that the pollutants are within the prescribed standard. Similarly, $0 <$ WQI < 100 indicates that the water is fit for human use and $90 <$ WQI < 100 reflects its suitability for human use (Table 2).

Table 3: Physico-chemical and biological properties of Dalvoy lake water in premonsoon, 2006.

Samples	DO (mg/L)	FC (MPN/100)	pH	Temp. °C	BOD (mg/L)	NO_3^- (mg/L)	PO_4^{-3} (mg/L)	Turbidity (NTU)	TS (mg/L)
PR06S1	4.3	1500	8.35	21.5	4	28	9.8	76	777
PR06S1	4.3	1500	8.35	21.5	4	28	9.8	76	777
PR06S2	3.6	1500	8.24	24	10	23	9.5	75	777
PR06S3	5.4	1500	8.39	22.4	2	26	9.1	76	774
PR06S4	6	1500	8.36	22.5	15	22	9.3	78	773
PR06S5	4.3	1500	8.41	21.3	9	18	9.4	74	798
PR06S6	4.8	1500	8.54	23.5	16	17	9.4	72	786
PR06S7	5	1500	7.82	23.5	5.5	17	9.5	70	796
PR06S8	4.6	1500	8.32	23.5	8.4	16	9.1	71	789
PR06S9	3.975	1500	8.39	23.7	10.46	18	8.2	76	790
PR06S10	5	1500	8.44	23.8	6.4	19	8.5	75	785
PR06S11	4.5	1500	8.28	24.5	8.64	24	8.6	73	837
PR06S12	4.8	1500	8.36	24.2	8.6	20	7.8	78	798
PR06S13	2.6	1500	8.36	22.9	15	16	8.6	79	786
PR06S14	4.9	1500	8.37	24.5	7.6	18	8.3	74	798
PR06S15	3.2	1500	8.48	24.5	10.5	23	7.5	71	773
PR06S16	8.6	1500	8.39	25.2	3.2	21	8	72	794
PR06S17	2.6	1500	8.39	25.9	14.14	20	8.6	73	792
PR06S18	6.8	1500	8.42	25.3	9.2	20	8.4	75	776
PR06S19	1.85	1500	8.25	24.6	12.3	18	9	76	795
PR06S20	6.1	1500	8.28	24.2	8	21	9.5	74	790
PR06S21	5.8	1500	7.44	25.6	6.5	13	9.3	78	829
PR06S22	6	1500	8.15	24.2	8.1	19	9	75	836
PR06S23	7.2	1500	7.47	23.8	4.2	13	8.6	74	812
PR06S24	6.8	1500	7.45	21.6	3	13	8.4	86	805
PR06S25	5.5	1500	7.49	24.5	5	14	8.2	80	817
Average	4.969	1500	8.193	24.5	8.70	18.81	8.38	75.33	795.3
Max.	8.6	1500	8.88	25.9	21.3	28	9.8	86	842
Min.	1	1500	7.44	21.3	1	13	5.6	70	748

*FC = Faecal coloiforms

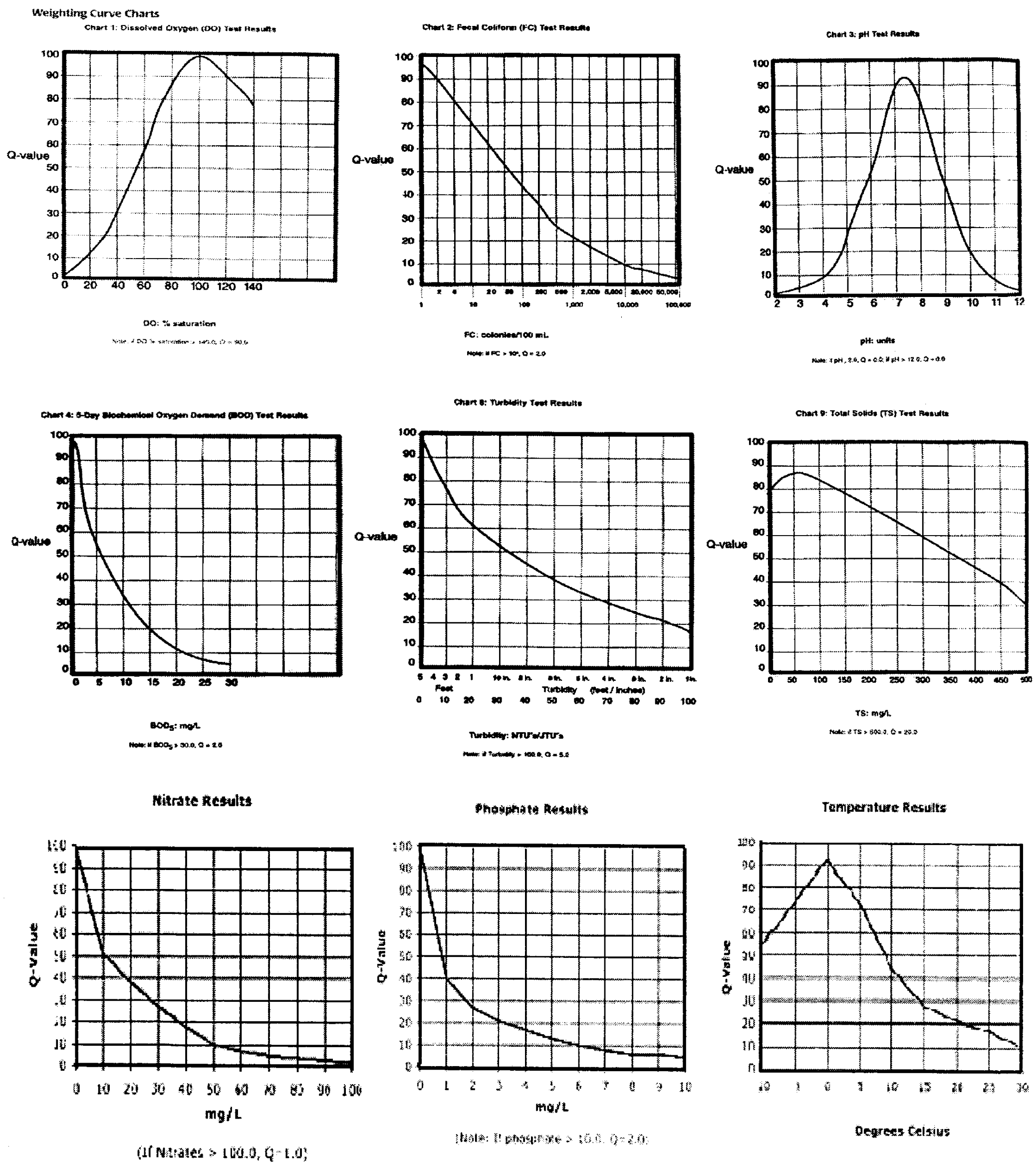

Fig. 3: Standard graph for Q- value of different factors.

In order to calculate WQI in NSF method, the quality index was determined by weight factors of NSF method. DO was converted to saturation percentage using Fig. 4 and temperature (water quality index calculation) based on temperature change from a reference site. In this study, a comparison was done for all sample sites with the S_1 in premonsoon and in postmonsoon.

CONCLUSION

Water pollution is not only an aesthetic problem, but a serious economic and public health problem

Table 4: Physico-chemical and biological properties of Dalvoy Lake water in postmonsoon, 2006.

Samples	DO (mg/L)	FC* (MPN/100)	pH	Temp. °C	BOD (mg/L)	NO_3^- (mg/L)	PO_4^{-3} (mg/L)	Turbidity (NTU)	TS (mg/L)
PT06S1	3.5	1500	7.86	21.5	4	25	6.2	70.1	752
PT06S2	1.9	1500	7.89	22.6	2	25	6.1	70.5	751
PT06S3	1	1500	7.99	21.7	16	25	6.5	70.2	756
PT06S4	5.4	1500	8.09	22.5	13	24	6.1	70.5	765
PT06S5	3	1500	8.78	21.8	15	25	6.2	70.6	789
PT06S6	5.6	1500	8.45	22.3	3	15	6.4	70.8	754
PT06S7	6.2	1500	8.86	23.2	6	15	6.5	71	760
PT06S8	6.4	1500	8.45	22.7	6	14	6	71.5	789
PT06S9	6.1	1500	8.88	22.3	2	15	8.5	73	792
PT06S10	4.9	1500	8.12	23.5	5	14	8.6	72.5	765
PT06S11	5	1500	8.14	22	1	15	5.6	73	799
PT06S12	3.7	1500	8.65	22.4	8	16	5.7	73.1	784
PT06S13	4.8	1500	8.66	22.5	6.5	18	5.9	73.5	784
PT06S14	3.1	1500	8.62	22.5	18.5	19	5.9	72	769
PT06S15	2	1500	8.35	22.8	21.3	23	6.1	71	748
PT06S16	5.95	1500	8.33	22.4	4.6	21	6.2	71.1	749
PT06S17	1	1500	8.21	22.4	15.6	18	6.4	71	798
PT06S18	3.5	1500	8.11	23.1	12.4	19	6.5	72.5	785
PT06S19	4.4	1500	8.11	22.4	8	20	6	73.5	769
PT06S20	5.3	1500	8.26	22.3	7.6	20	9.3	75.5	780
PT06S21	5.4	1500	8.45	23.7	7.4	16	9	74	810
PT06S22	2.4	1500	8.22	22.4	10.7	19	8.6	73.6	842
PT06S23	3	1500	8.44	22.1	8.7	15	8.4	75	812
PT06S24	5.45	1500	8.62	22.1	4.65	13	8.2	75.5	800
PT06S25	5.8	1500	8.2	22.7	10.4	14	8.7	74.2	812
Average	4.192	1500	8.3496	22.5	8.694	18.52	6.944	72.368	780.56
MAX	6.4	1500	8.88	23.7	21.3	25	9.3	75.5	842
MIN	1	1500	7.86	21.5	1	13	5.6	70.1	748

Table.5: Parameters by using fixed weight (W_i) and obtain the quality index (Q_i) by using the Q-value of standard graphs.

Factor	W_i	Average of pre monsoon	$(Q_i)_1$	$(W_iQ_i)_1$	Average of post monsoon	$(Q_i)_2$	$(W_iQ_i)_2$
DO (sat. %)	0.17	4.969	87	14.79	4.192	60	10.2
FC (MPN/100)	0.16	1500	20	3.2	1500	20	3.2
pH	0.11	8.193	77	8.47	8.3496	72	7.92
BOD (mg/L)	0.11	8.4296	40	4.4	8.694	39	4.29
ΔT^{*}(°C)	0.1	24.5-21.5=3	81	8.1	22.5-21.5=1	89	8.9
PO_4^{-3} (mg/L)	0.1	4.8622	14	1.4	6.944	8	0.8
NO_3^- (mg/L)	0.1	19.08	38	3.8	18.52	38	3.8
Turbidity (NTU)	0.08	75.24	27	2.16	72.368	28	2.24
TS (mg/L)	0.07	795.3	20	1.4	780.56	20	1.4
~	~	~	$\Sigma(W_iQ_i)_1$	47.72	~	$\Sigma(W_iQ_i)_2$	42.75

as well. Periodical monitoring of the water quality will be helpful in saving the lake from further degradation. The results obtained in this investigation provide the characteristics of water with most of the parameters within the permissible limits prescribed. The WQI was found to be around 47.72 in premonsoon and 42.75 in postmonsoon for this lake showing very poor quality of water for drinking purpose, but the overall quality of waters in Dalvoy lake is suitable for agriculture.

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